In Two Sections

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FUTURE MEETINGS

of the

American Institute of Electrical Engineers

Place	*Dates*	*Nature*	*Latest Date for Receipt of Manuscripts*
Lake Tahoe, Calif.	Aug. 25-28, 1931	Pacific Coast Convention	(Closed)
Kansas City, Mo.	Oct. 22-24, 1931	District Meeting	July 22, 1931
New York, N. Y.	Jan. 25-29, 1932	Winter Convention	Oct. 26, 1931
Milwaukee, Wis.	March 14-16, 1932	District Meeting	Dec. 14, 1931
Providence, R. I.	May - 1932	District Meeting	Feb. - 1932

NOTE: Members who are contemplating submitting papers for presentation at any of the above meetings should communicate promptly with Institute headquarters, 33 West 39th Street, New York, N. Y., so that their papers may be docketed for consideration by the Meetings and Papers Committee, as programs for all meetings are formulated several months in advance. Upon receipt of this notification, Institute headquarters will mail to each prospective author information in regard to the Institute's rules relating to the preparation of manuscript and illustrations.

MEETINGS OF OTHER SOCIETIES

CAMP COOPERATION XI—Association Island, Henderson Harbor, New York (Society for Electrical Development, 420 Lexington Avenue, New York City) July 27-31.

ROCKY MOUNTAIN DIVISION N. E. L. A., annual convention, Stanley Hotel, Estes Park, Colo., September 2-4, 1931.

ILLUMINATING ENGINEERING SOCIETY, annual convention, Pittsburgh, Pa., October 13-16, 1931.

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This Month—

Front Cover

Lightning—as seen from the mountains overlooking Los Angeles and Pasadena, California
—General Electric Co. Photo

Relay Protection for a "Close-Linked" System 471
By T. G. LeCLAIR

Overseas Radio Telephone Service 476
By F. A. COWAN

Theoretical Studies, Laboratory and Field Tests, Operating Experiences, Lead to Effective System Protection Against Lightning Disturbances 478

Theories of Lightning Discharge and Traveling Waves . 481

Field Tests with Artificial Lightning 487

Field Tests with Natural Lightning 490

Protection Against Lightning Surges 498

Lightning vs. System Operation 501

—— Turn to Next Page

Single Patent Appeal Court is Proposed 502
By EDWIN J. PRINDLE

Twin Motors for Heavy Rolling Mills 506
By R. H. WRIGHT & H. E. STOKES

A Vacuum-Tube Device for Current-Balance Telemeters . . 510
By B. E. LENEHAN & PAUL MacGAHAN

Coordination—The Essence of Modern Engineering 512
By W. S. LEE, President, A. I. E. E.

Short Items—

Magnetic "Iron" Perfected by Research 475

Clinical Sunlight—Natural and Artificial 511

News of Institute and Related Activities 514

Local Institute Meetings 526

Employment Notes 531

Membership 534

Engineering Literature 535

Industrial Notes 540

Officers and Committees (For complete list see ELECTRICAL ENGINEERING January 1931 pp. 81-84.)

THE LIGHTNING SEASON being at hand, it is pertinent that serious attention be given to the effects of this phenomenon upon electric power transmission. Much has been accomplished by the Institute's lightning subcommittee since its appointment in 1926; the work has been greatly expedited within the past two years by the use of several new instruments, and by the concentration of effort upon a few systems. Important results of recent investigations, contained in twelve Institute papers, have been abstracted and correlated in six articles. (*See pages 478 to 502.*)

PACIFIC COAST convention with its excellent technical program embracing subjects from cathode drops to industrial applications, and its delightful admixture of recreational and entertainment features, offers first-class vacation possibilities. Why not take advantage of the special convention rates available at Tahoe Tavern for the entire convention week? (*See page 514.*)

ANNUAL MEETING of the Institute comprised the opening session of the summer convention; results of the recent election of officers, and the annual report of the board of directors, were among the important matters receiving attention. (*See page 522.*)

DR. W. J. FOSTER (F'16) recently awarded the Lamme Medal, was presented the trophy with appropriate ceremony during the summer convention. (*See page 519.*)

"FOR THE PURPOSE of studying the present and any proposed future activities of the Institute," the new Institute policy committee was appointed at the May 19 meeting of the board of directors. (*See page 523.*)

H. B. SMITH (F'13) past-president of the Institute, has resigned his post at Worcester Polytechnic Institute, and plans to resume professional practise. (*See page 524.*)

W. S. LEE (F'13) sagacious president of the Institute, in his summer convention address interprets the spirit of modern engineering in one word—*coordination*—and indicates therein a fruitful field of endeavor for the young engineer. (*See page 512.*)

STEEL MILL engineers especially may be interested in the development of twin-motor drive for heavy rolling mills. (*See page 506.*)

SUMMER CONVENTION news will be especially interesting to those unable to attend and participate in its varied technical and recreational program. (*See page 517.*)

OVERSEAS TELEPHONE service by radio first was introduced more than four years ago and now is accepted as quite the ordinary thing. Recent developments are described by F. A. Cowan (M'29). (*See page 476.*)

Relay Protection for A "Close-Linked" System

Relay-protection design involves a detailed study not only of the required standards of service but also of the general design and layout of the power system to be protected. The "close-linked" type of system of Chicago and the special relaying system which it demanded, are discussed.

By
T. G. LeCLAIR
Member A. I. E. E.

Commonwealth Edison Co., Chicago, Ill.

SERVICE RELIABILITY required of electric power systems today is accomplished fundamentally by two general means. One might be termed "preventive engineering" and the other "protective engineering." The former presupposes a system and its related equipment designed and built to a degree of perfection that makes failure impossible while the latter aims to minimize and localize such troubles as may occur.

Obviously, *complete* prevention of failure is impossible of practical attainment; hence protection against line and apparatus failure becomes a necessity. Theoretically a fault is not considered serious provided the capacity and extent of equipment involved is small and that the protective equipment will operate to isolate the trouble quickly. From a power-system standpoint, therefore, protective devices are installed to protect the system as a whole, rather than individual lines or equipment, against the disturbing effects of faults.

General System Design

Of first importance in the matter of power-system protection is the question of the general system design; and so far as the larger cities of the United States are concerned, this may be classified into three principal types as follow:

1. "Loose-linked" system of Detroit.

Each group of distribution circuits is provided with a substation and for each group of substations there is a generating station of sufficient normal capacity to care for the group of substations operating from its buses. The loose-linking characteristic is found in interconnection of areas which are served by different generating stations with tie cables so designed as to have relatively low capacity compared to the total load emanating from a generating station, but of sufficient capacity to serve normal and emergency power interchange between different load districts. Thus, the different load areas are all linked together for normal service, but each is subject to quick and complete isolation from its neighbors, minimizing the possibility of any system-wide disturbance which might result from a serious fault in any load district. (See A. I. E. E. Trans., Vol. 48, Oct. 1929, pp. 1080-2.)

2. "Synchronized-at-the-load" system of New York.

All supply cables are short; generating stations are close to the load and all are of closely similar efficiency. Transmission and tie-lines are so arranged that any station may feed to any or all load centers Thus the loss of any one source will not interrupt service at the load; power is widely available under emergency conditions and yet relatively low short-circuit currents arise, a factor of prime importance. (See A. I. E. E. Trans., Vol. 48, Oct. 1929, pp. 1080-2.)

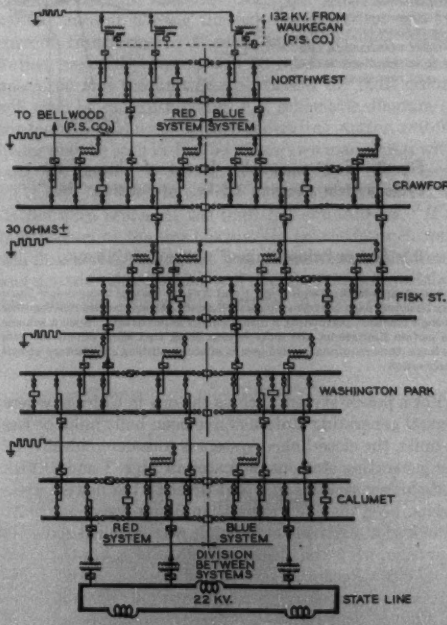


Fig. 1. Schematic diagram of Chicago "close-linked" transmission system. Note especially that system is normally divided into two distinct parts ("red" and "blue"), also that generating stations are connected by 66-kv. low-reactance tie cables

From a talk presented informally at a joint meeting of the Chicago Section of the A. I. E. E., and the Western Society of Engineers, held in Chicago, Oct. 23, 1930. Not published in pamphlet form.

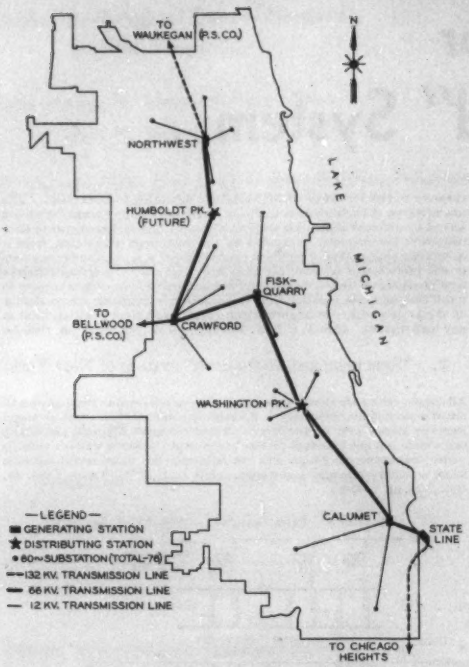


Fig. 2. Semi-geographic layout of Chicago 60-cycle system showing 66-kv. inter-station "bus"

3. Bus or "close-linked" system of Chicago.

This system is illustrated in Figs. 1 and 2 where various independent loads may be noted, each fed from separate sources. All sources are tied together through reactors, permitting a direct energy interchange. Such a scheme has certain limitations, the most serious being that short-circuit currents are large, thus requiring special means of accomplishing satisfactory circuit interruption.

For a power system such as the one in Chicago where several generating stations have been built more or less as units, the close-linked system is considered ideal. Of the generating stations indicated in Figs. 1 and 2, Fisk and Quarry stations are "old-timers," the newest units having been installed more than fifteen years ago. At Crawford station the oldest unit was installed some six years ago, while the oldest at State Line is less than two years old. Because operating efficiencies among these stations vary greatly, it is necessary to provide for a transfer of load between different sources in order to realize the best over-all operating economy.

This load transfer is accomplished through a 66-kv. "inter-station" bus which stretches the entire length of the city as may be seen in Fig. 2. All six steam-electric generating stations representing the aggregate installed capacity of 1,298,000 kw. are interconnected by

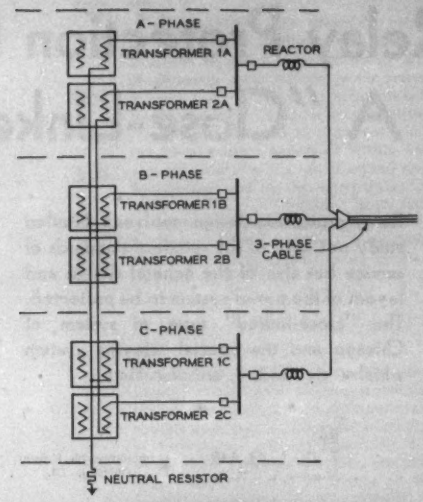


Fig. 3. Illustrating isolated-phase grouping of two transformer banks

means of this 66-kv. transmission bus. Electrically these station interconnections are extremely short, their reactance being so low that with maximum load the total voltage variation from one end of the city to the other does not exceed three or four per cent.

With this system it is possible to tap off at any given station the load needed for that particular local territory the transformer capacity of the station in question being governed of course by the load to be served. However, there are certain difficulties involved because with this close-linked system any one fault member will involve the entire system. For this reason the system has been split throughout into two parts. The 66 kv. buses of the two parts are capable of interconnection in the various stations but only in rare cases are they actually operated tied together. Thus, there are practically two duplicate systems; and trouble on one of them will not interfere with the other. For purposes of clarity some of the illustrations refer to these two parts as "red" and "blue" systems.

Isolated-Phase Construction

Short-circuit current which would arise if the two systems were operated tied together would be practically impossible to handle with the existing circuit-interrupting equipment and conventional group-phase construction. Even with the systems separated, the problem of handling the interruption of fault current is a serious one. An expedient which has done more than any other single thing to make practicable the opera-

tion of such a system is the isolated-phase construction. With this type of construction it is possible to throw the entire station capacity upon one bus, where emergencies require, yet the short-circuit current is low enough so that an ordinary circuit breaker can interrupt it satisfactorily.

A diagrammatic presentation of this isolated-phase arrangement is given in Fig. 3 where two transformer banks are shown so connected that both the phase unit of the bank itself and the phase leads from the bank are widely separated physically from those of adjacent phases. The leads are not brought close together until they have passed through suitable reactance capable of limiting the short-circuit current to an easily interruptable value.

Most important among the features of the isolated-phase system is the relatively-high resistance or reactance employed in the neutral connection. Normally, in a star-connected system all loads are carefully balanced between phases and practically no current flows through the neutral; on the other hand in the isolated-phase system, practically all fault current will flow through the neutral since phase-to-phase faults are almost impossible on account of the great physical separation between exposed parts. This greatly simplifies the protection problem without interfering in any way with the system regulation.

With the isolated-phase construction of a 66-kv. outdoor terminal not only are the phase leads separated by a distance of 30 ft. or more, but by a metal screen of generous proportions as well. (See Fig. 4.) In indoor generating station construction whether for 12 kv. or 66 kv. each phase is housed in a separate room or on a separate floor. This type of construction is used also for the newer and larger substations; in the older and smaller substations the arrangement of lines and buses is depended upon to prevent complete shut-downs. No two lines to a substation group originate on the same line bus but are divided among the different sections of the generating station main bus.

Fault Bus for Protecting Switching Equipment

As mentioned in the beginning of this article, protective equipment must be installed to guard against the disturbing effect of those failures which system design cannot prevent. To be ideal, of course, protective devices must disconnect faulty equipment only, and in addition operate instantaneously; this ideal is achieved or approached wherever economically justifiable.

Practically instantaneous clearing of faults can be secured by employing the fault bus, a device for system protection which is of maximum benefit with isolated-phase construction. It consists essentially of a separate bus isolated from ground but connected through a current transformer to the main ground bus. Each unit group of switching equipment has its own fault bus through which the oil switch tanks, insulator bases, and other equipment cases are grounded and to which flash plates are connected. These flash plates are so arranged that no flashover can occur without the resultant current flowing through the fault bus and its current transformer. A relay in this current transformer secondary circuit can be set for instantaneous operation and the unit group wherein the fault occurs will then be quickly isolated. A schematic diagram of the fault-bus connections in a generating station switchhouse may be seen in Fig. 5. Here two main buses with outgoing lines are connected to so-called line buses; all can be fed from either one of the main buses. The dotted lines represent the fault-bus connections. If a fault occurs on the line bus marked (x) the fault current will flow through the fault bus and current transformer and actuate relay 3 which will trip the four line switches and also the two group switches A and B, thereby

Fig. 4. Outdoor 66-kv. switching terminal at Calumet generating station. Note isolated-phase construction and high screen barriers between phase groups

isolating the fault. For faults between two unit groups, time sequence relaying is employed to prevent unnecessary switch-openings. For instance, if a fault occurs on switch *E*, relay 4 will first trip the line and group switches; and if the fault is not cleared within 0.7 sec., relay 7 will trip all switches connected to the red main bus section where switch *E* is connected.

Fault buses are now installed in all new generating stations, distribution stations, 66-kv. terminals and some of the larger substations to protect against bus and equipment failures.

Differential Relay Protection for Generators and Large Transformers

A differential method of relaying is employed to disconnect faulty generators and 66-kv. transformers from the system. For generator protection the simple conventional scheme with a sensitive relay is used. For three-winding transformers, however, this simple arrangement cannot be used, especially where one or two windings are equipped for tap changing under load. Further difficulties are encountered because of the 30-ohm neutral resistance in the 66-kv. system; consequently, one set of relays is connected differentially across all three windings. (See Fig. 6.) These relays are of the *percentage differential* type; that is, they will trip when the tripping current exceeds a predetermined percentage of the load current. (See "Percentage-Differential Transformer Protection," p. 361, May 1931 issue of Electrical Engineering.) On account of the tap-changers, this percentage for these relays must be relatively high, a value of 50 per cent being used. For faults on the 66-kv. winding close to the neutral, because of the neutral resistor limiting the fault current, a more sensitive relay is required. A second set of differential relays, connected across the 66-kv. winding, and with a setting as low as from 2.5 to 5.0 per cent, is therefore provided. In addition to the differential relays, ordinary overload relays are installed on the 12-kv. side of main and regulating transformers.

Pilot-Wire Relaying for Tie-Line Protection

As shown in Fig. 1 the 66-kv. tie lines between generating stations are connected to buses at the transmission terminals, these buses being divided into several sections and operated split or tied together depending upon the system requirements. The best way known to isolate instantaneously a faulty line on this type of system is the pilot-wire-relay scheme. This system, while rather costly, is justified by the size of the lines and the importance of the service. A three-phase scheme is employed with four pilot wires, pilot transformers, balancing resistors, and capacitors. It has been found that the capacitors can be omitted in the Chicago system, where the lines are all less than eleven miles long.

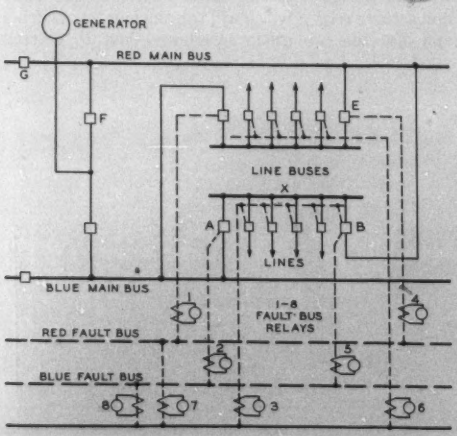


Fig. 5. Schematic diagram for typical section of fault bus

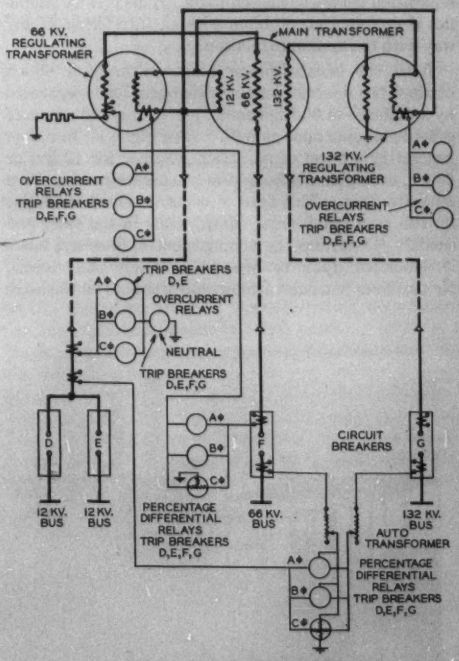


Fig. 6. Connection diagram of percentage-differential relays for protecting three-winding tap-changing transformers

Sectionalization

In addition to the usual protective schemes, there are in use on this system means for preventing the spread of trouble; these cannot be classed with protective devices. As previously mentioned, the 66-kv. system is divided into two parts which are normally operated as independent units, so that trouble on one-half cannot affect the other half, even should the protective devices fail. On the 12-kv. system, the stations also are separated into two or more parts for the purpose of preventing the spread of trouble. These two parts may be permanently separated through reactance, which will limit the flow of short-circuit current; or they may be operated normally tied together and automatically sectionalized by relays. Normally these sectionalizing relays will not interrupt any service but are intended to separate each section and its dependent lines into a number of self-sustained units. In this way, failure of protective devices on one of these units will not spread the trouble to the other units.

Substation and 12-Kv. Line Protection

The isolated-phase construction with fault-bus protection has been extended to some of the later and larger substations; in others, line relays are relied upon for the proper clearing of faulty buses. For line protection, ordinary overload directional and balanced differential relays are used.

Up to a few years ago, the systems so far touched upon would have been all that required consideration when planning reliable supply for a city like Chicago. Now, however, some of these stations are shut down part time and more efficient generating capacity outside of Chicago is depended upon for the supply. This energy is delivered over long overhead transmission lines and their protection becomes part of the problem of service security.

One great difficulty with overhead lines is their susceptibility to lightning—a problem not yet completely solved. Still another problem to consider when large amounts of power are transmitted over great distances is that of stability. Several means for increasing the stability of a line have been introduced, however, most common among which are, (1) increasing the speed of clearing faults; (2) providing high speed excitation; and (3) changing system connections.

Conclusion

Past progress toward the goal of perfectly reliable service has been along three principal paths; namely, (1) improving the individual units of equipment, (2) providing faster and more reliable isolating devices, and (3) designing the complete system so that the loss of individual parts may be tolerated. In the future the metropolitan system should make its greatest advances along the line of general system developments based upon the present high quality of equipment. Marked improvement in the reliability of long overhead lines with a high degree of exposure may be expected, particularly when the power delivered must meet the exacting standards of metropolitan service.

Magnetic "Iron" Perfected by Research

THIRTY years ago great quantities of iron were necessary in cores of electrical devices to prevent undue electrical loss. High temperatures caused magnetic deterioration of the metal. Even alloys of apparently constant chemical composition had varying magnetic properties. In view of this obstacle, progress in transformers of electrical currents was especially difficult.

Then came the first big improvement; Hadfield in England discovered silicon as an alloying element with iron. In 1903 silicon steel appeared there, and a little later here. This new steel cut losses in half. They were again cut in half by better mill practise and improved raw material. For the next decade further progress was slow, improvements small. Things had again reached an impasse.

About that time, an effort was made by the writer at the University of Illinois to make iron alloys of only the purest materials obtainable. For nearly sixteen years the research has continued; one of its main objects being to determine the properties of really pure iron, because iron is the basis of all important magnetic materials. Who would have believed that the elimination of a few thousandths of one per cent of carbon could be responsible for raising the maximum permeability of iron from perhaps 10,000 to 50,000 with corresponding decreases in hysteresis? Yet this has been amply demonstrated.

The work has been fraught with exceptional difficulties since it dealt with subjects like strain in the crystal structures, and with impurities in thousandths of one per cent. Furthermore, these very small amounts of oxygen, carbon, and sulphur exist in solution in solid iron—like sugar in solution in a glass of water.

Commercially, the most important results have come from the study of iron-silicon and iron-nickel alloys. Laboratory results are not rapidly translated into commercial practise. Five years after the first published results, no appreciable effect appeared in commercial steel. In 1920, after much discussion and many experiments, the steel mills began to put some of the

From an article written by Dr. T. D. Yensen of the Westinghouse Research Laboratories for *Research Narratives*, Feb. 15, 1931, published by the Engineering Foundation, Inc., 29 West 39th Street, New York, N. Y.

findings into practise and there has since been a steady annual improvement in the quality of electrical sheet iron. Now the commercial material is almost as good as the laboratory product of a few years ago.

Hipernik (an alloy of half iron and half nickel) is another product of the laboratory. At first used in high-quality radio receiving sets where it contributed largely to the elimination of distortion of sounds in reproduction, it has gradually entered other important fields. In the near future we may find this alloy in many places where iron-silicon alloys are used today. Here again the difference between the ordinary alloy and hipernik cannot be ascertained by usual chemical analysis; radically new methods had to be devised.

(EDITOR'S NOTE: Under date of May 25, 1931, the American Rolling Mill Company, Middletown, Ohio, announced that this special alloy now is being rolled commercially from 6-ton ingots.)

Associates who have contributed to this success include G. H. Cole,[1] A. A. Frey, T. Spooner[2] and N. A. Ziegler. In its large practical results, this long and painstaking research is a vivid example of how the affairs of men are affected by scientific work which only a few years ago would have appeared hopelessly theoretical.

Overseas Radio Telephone Service

More than four years have elapsed since the installation of the first transoceanic radio-telephone circuit between New York and London. Some of the more recent developments in this class of service are discussed here.

By
F. A. COWAN
Member A. I. E. E.

American Tel. & Tel. Co., New York, N. Y.

SHORT-WAVE RADIO has played an important part in the extension of the telephone frontiers beyond the boundaries of this North American continent. During the four years which have elapsed since the first commercial telephone service between this country and Europe was inaugurated all of the world's overseas telephone extensions have employed short-wave radio. With the exception of the original New York-London circuit which operates on 1,500 m., the wavelengths used have ranged between 14 and 100 m. Today there are three short-wave circuits between New York and London supplementing the original long-wave circuit. In addition to these there is a circuit between New York and Buenos Aires, Argentina, circuits from New York to ships at sea, and one from London to Sidney, Australia (See Fig. 1). All of these circuits are available to telephone users in this country, and in addition to these facilities, extensions are being planned between New York and Hamilton, Bermuda, New York and Rio de Janeiro, and San Francisco and Honolulu, Hawaii. Since such factors as susceptibility to noise in transmission across equatorial regions, and the character of other transmission variables, including economic considerations, favor the use of short *vs.* long waves, all of these circuits will employ short-wave radio.

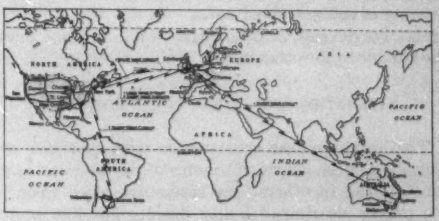


Fig. 1. Radio links between telephone systems of North America and other countries

NEW YORK-BUENOS AIRES CIRCUIT

A schematic layout of the New York-Buenos Aires circuit may be seen in Fig. 2. A crystal-controlled high-powered transmitter employing water-cooled vacuum tubes with an output of between 15 and 20 kw. is employed at both terminals. Associated with this transmitter are directive antennas which increase the signal strength by an amount equivalent to a 20- to 50-fold increase in transmitted power. Upon leaving the transmitting station, signals travel by the well-known sky-wave route to the foreign terminal. Radio receiving stations of the double-detection type equipped with automatic gain control and directive antennas are employed. To care for the changing transmission conditions these directive antennas are provided for three separate wavelengths. The received speech signals are transmitted from the receiving station to the foreign subscriber over land lines.

These directive-antenna arrays improve the receiving conditions by strengthening the signal received from the selected direction, reducing the effect of noise and other

From "Recent Developments in the Operation of Radio Telephone Service," (No. 31-37) presented at the A. I. E. E. Middle Eastern District meeting, Pittsburgh, Pa., March 11-13, 1931.

1. Member '27. 2. Fellow '29.

signals coming from other directions. The automatic gain-control feature compensates for moment-to-moment variations in the strength of the received carrier wave and when radio noise conditions are satisfactory the complete receiving system is capable of satisfactorily utilizing a signal having a field strength as low as one microvolt per meter. This performance has been made possible by the selection of a receiving site sufficiently isolated to minimize local interference,

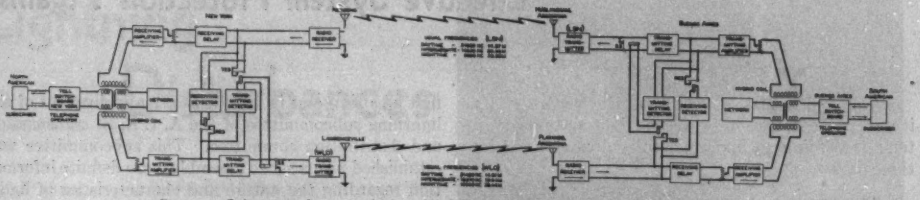


Fig. 2. Schematic layout of New York-Buenos Aires radio-telephone circuit

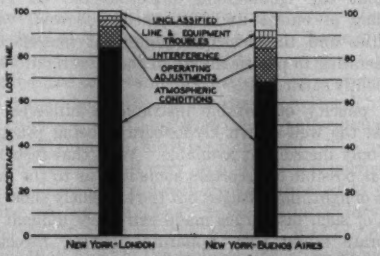


Fig. 3. Analysis of time lost on two short-wave radio-telephone circuits for a typical summer month

and by the careful design of the component parts of the receiving system.

At the terminal points voice-operated-relay switching equipment disables the radio path in one direction while speech is traveling in the opposite direction. It also maintains the transmitting side of the circuit in a disabled condition when no speech is being transmitted. This automatic switching simplifies the transmission problem by resolving the two-way circuit into two one-way circuits. The switching-relay circuits are carefully adjusted to compensate for any changing transmission conditions, thus minimizing interruptions due to false operation of the relays.

Once the circuits of the type under consideration have been established their performance is controlled largely by the condition of the transmitting medium at any particular time. Since the control of this medium is beyond the scope of human endeavor, the operating problem becomes one of maintaining the component parts of the system in good condition and operating the system as a whole to best advantage.

Lost Circuit Time Analyzed

A comparative analysis of the lost circuit time for a typical summer month on the New York-Buenos Aires circuit and one of the New York-London short-wave circuits, is shown in Fig. 3. It may be noted in each case that the major percentage of lost time is due to atmospheric conditions.

Whereas normally the conditions are good, there are times when, due to some disturbances of a nature not clearly understood, radio transmission from certain paths is seriously affected. These disturbances have been correlated reasonably well with abnormal activity in the magnetic field of the earth and are commonly known as "magnetic storms."

These occur at irregular intervals and at times result in reducing the signal strength at the receiving points to unusable values. Transmission on all frequencies is affected to a greater or lesser degree, and the time in each 24-hr. period during which reliable transmission can be expected is materially reduced. This interference usually is seriously effective for several days preceding and following the day on which the storm is actually at its height.

The equipment used in the short-wave radio circuits is so designed and constructed as to minimize the likelihood of trouble. In addition, spare units of equipment have been provided for replacing equipment which would be most subject to trouble or which would require considerable time to repair. These precautions, together with a systematic testing routine, account for the small amount of lost time due to equipment troubles.

In view of their adaptability to transmission over great distances and the rapid progress that is being made in improving, simplifying, and reducing their cost, short-wave radio systems are of outstanding importance in the development of world-wide telephonic communication. What the future will bring can only be guessed; but it does seem reasonably certain that for the next few years the short-wave circuits will continue to occupy a prominent position in the forward march toward the development of a world-wide telephone service.

That the concerted efforts of power companies and electrical manufacturers to combat the disturbing influences of lightning already have borne fruit, is attested by the greatly reduced transmission line outages from this cause. Results of recent investigations in this field as described in twelve Institute papers form the basis for the six articles which follow.

Theoretical Studies Laboratory and Field Tests Operating Experiences Lead to Effective System Protection Against

THE LIGHTNING PROBLEM as it affects the operation of electric light and power systems, according to Sporn logically divides itself into three parts:

1. Theoretical and laboratory investigations which include mathematical studies and various analyses of lightning phenomena.

2. Field research with natural and artificial lightning, which studies are enhanced from year to year by developments and improvements in equipment.

3. Evaluation of the effects of different devices and of line design upon the mitigation of lightning disturbances by the study and analysis of practical operating records.

This and the five articles following in this issue of ELECTRICAL ENGINEERING present a collection of theories and facts relating to these different aspects of the lightning problem. These articles have been prepared from twelve Institute papers (see Table I) of which three treat mainly the theories involved in lightning studies; two deal entirely with field investigations of surges imposed on transmission systems by means of artificial lightning discharges; four present the results of field investigations of natural lightning discharges; one gives the results of analysis and interpretation of a large quantity of operating data collected on systems in service; while one is devoted to a description of a new device designed to protect line insulators against flashovers.

An attempt has been made to correlate information from these different sources, outlining in some detail the most recent findings in this important field, and indicating the relation between these latest disclosures and previously accepted ideas. Additional information has been obtained quite recently regarding the mechanism of lightning formation and discharge, and some new theories have been advanced. It is realized generally, however, that present ideas still are entirely inadequate for a thorough understanding of the fundamental nature of lightning. Nevertheless, in spite of the obscurities, several important disclosures have been made. These are outlined in the paragraphs that follow and are based upon the results given in the entire set of twelve papers.

Concerted action in theoretical and field studies of natural and artificial lightning phenomena received its first great impetus in 1926 with the appointment of the lightning subcommittee of the A. I. E. E. transmission and distribution committee. This subcommittee was established primarily to assemble more definite information regarding the nature and characteristics of lightning and related electric system disturbances; also to ascertain possible protective measures with which to combat the troublesome disturbances. A general pooling of efforts and equipment followed, various utilities and the principal equipment manufacturers cooperating in practically all of the investigations subsequently carried out.

A paucity of suitable instruments hindered early work, the well-known klydonograph being practically the only instrument available. With that instrument it was possible to ascertain some idea as to the magnitude of lightning voltages, but the extremely short duration of such discharges made extremely difficult their accurate study with apparatus having mechanical recording elements. Development of new instruments and their liberal use, and the concentration of major field efforts upon a relatively few representative systems have been the two factors chiefly responsible for the rapid acceleration of lightning studies during 1929 and 1930.

DIRECT HITS AND INDUCED SURGES

Line surges can be very harmful whether due to direct hits or to induction from cloud discharges or strokes to nearby objects. It is generally recognized, however, that disturbances arising from direct strokes to line conductors or to ground wires on well grounded steel structures, subject lines to more severe punishment than do induced surges in general. The induced surge appears to be of minor importance on lines as highly insulated as are the 220-kv. lines in eastern Pennsylvania and New Jersey. Of course, voltages also can be induced on the conductors when a direct hit on the tower or ground wire occurs. Whether or not these induced voltages will cause a flashover appears to depend upon line insulation and tower footing resistance.

Lightning Disturbances

Westinghouse E. & M. Co. Photo

Wave Shapes

Wave shapes of lightning surges depend upon many varying factors, chief among which are the origin of the surge (whether induced or due to a direct stroke), duration of cloud discharge, and cloud height. Some of the many cathode-ray oscillograms which have been taken both of induced surges and direct strokes are reproduced in this symposium. Wave fronts varying in length from 2 to 9 microsec. with length of tail to half-voltage of from 6 to 40 microsec. have been observed. The total lengths of these waves vary from 10 to 160 microsec. In an oscillogram of a direct stroke estimated as terminating on the line 125 ft. from the laboratory, a voltage rise of 1,540 kv. per microsec. was recorded (see Fig. 16). Most of the oscillograms, however, were obtained at some distance from the point of incidence and, therefore, do not show the true wave shape at that point, having suffered distortion in traveling along the line.

Negative surges have steeper fronts than do those of positive polarity. It has been estimated that the former may have fronts as short as 1 microsec. or less, while the probable minimum for the latter is approximately 5 microsec.

Attenuation, Distortion, and Reflection

Traveling waves arising from lightning discharges undergo a continuous change as they proceed along the line, the general tendency being a slowing down of the front, a flattening of the tail, and a general increase in total length. Corona appears to be the greatest cause of this phenomenon; hence it follows that the reduction in wave crest is more rapid above than below the critical corona voltage. Attenuation is more rapid for extremely high-voltage surges and according to indications may be as high as 1,000 kv. per mi. of travel.

Surges impressed upon three parallel conductors evidence a more rapid slowing down of front but lower rate of attenuation than do waves on a single conductor. Reflections from line sections of changing impedance and from terminal equipment also are factors in wave shape change; characteristics of these reflections can be predicted by means of "lattice" diagrams.

Crest Voltages and Currents

The maximum voltage recorded in any of the tests described was 5,000 kv., measured on a wood pole line at a point about 4 mi. from the point of incidence of a direct stroke (see Fig. 21). Indications are that the voltage of a direct stroke may be as high as from 10,000 to 15,000 kv. A maximum discharge current of 670,000 amperes was reported, determined by adding together the tower ground currents for the several towers affected. This method may be subject to some errors; its merits are a controversial matter. Other indications, however, also point to a maximum of several hundred thousand amperes.

Polarity

No definite conclusions have been drawn in regard to polarity, but it seems well established that both positive and negative cloud potentials exist. However, more di-

Table I—Identification Data Pertaining to Lightning Papers Abstracted in This Group of Articles

Authors names	Company affiliations	Pamphlet copy titles	Serial numbers	Presented at	Dates presented
Edgar Bell Associate A. I. E. E. **A. L. Price** Associate A. I. E. E.	Penn. Pwr. & Lt. Co., Hazleton, Pa. Penn. Pwr. & Lt. Co., Hazleton, Pa.	Lightning Investigation on the 220-Kv. System of the Penn. Pwr. & Lt. Co. (1930)	31-89	District meeting, Rochester, N. Y.	April 29–May 2, 1931
L. V. Bewley Associate A. I. E. E.	Gen. Elec. Co., Pittsfield, Mass.	Traveling Waves on Transmission Systems	31-4	Winter convention, New York	Jan. 26–30, 1931
Otto Brune Associate A. I. E. E. **J. R. Eaton** Associate A. I. E. E.	Gen. Elec. Co., Pittsfield, Mass. Consumers Pwr. Co., West Jackson, Mich.	Experimental Studies in the Propagation of Lightning Surges on Transmission Lines	31-85	District meeting, Rochester, N. Y.	April 29–May 2, 1931
J. C. Dowell Associate A. I. E. E.	Gen. Elec. Co., Pittsfield, Mass.	Attenuation and Successive Reflections of Traveling Waves	31-42	Winter convention, New York	Jan. 26–30, 1931
C. L. Fortescue Fellow A. I. E. E. **R. N. Conwell** Fellow A. I. E. E.	West. Elec. & Mfg. Co., Pittsburgh, Pa. Pub. Serv. Elec. & Gas Co., Newark, N. J.	Lightning Discharges and Line Protective Measures	31-82	District meeting, Rochester, N. Y.	April 29–May 2, 1931
I. W. Gross Associate A. I. E. E. **J. H. Cox** Associate A. I. E. E.	Am. Gas & Elec. Co., New York West. Elec. & Mfg. Co., E. Pittsburgh, Pa.	Lightning Investigation on the Appalachian Elec. Pwr. Co's. Transmission System	31-86	District meeting, Rochester, N. Y.	April 29–May 2, 1931
W. W. Lewis Member A. I. E. E. **C. M. Foust** Associate A. I. E. E.	Gen. Elec. Co., Schenectady, N. Y. Gen. Elec. Co., Schenectady, N. Y.	Lightning Investigation on Transmission Lines—II	31-87	District meeting, Rochester, N. Y.	April 29–May 2, 1931
F. W. Peek, Jr. Fellow A. I. E. E.	Gen. Elec. Co., Pittsfield, Mass.	Lightning, Characteristics — Induced Voltages—Direct Strokes—Coordination — Transmission Line Design	31-88	District meeting, Rochester, N. Y.	April 29–May 2, 1931
R. R. Pittman Associate A. I. E. E. **J. J. Torok** Associate A. I. E. E.	Ark. Pwr. & Lt. Co., Pine Bluff, Ark. West. Elec. & Mfg. Co., East Pittsburgh, Pa.	Lightning Investigation on a Wood Pole Transmission Line	31-10	Winter convention, New York	Jan. 26–30, 1931
Philip Sporn Fellow A. I. E. E.	Am. Gas & Elec. Co., New York	1929 Lightning Experience on the 132-Kv. Transmission Lines of the Am. Gas and Elec. Co.	31-20	Winter convention, New York	Jan. 26–30, 1931
Philip Sporn Fellow A. I. E. E. **W. L. Lloyd, Jr.** Member A. I. E. E.	Am. Gas & Elec. Co., New York Gen. Elec. Co., Pittsfield, Mass.	1930 Lightning Investigations on the Transmission System of the Am. Gas and Elec. Co.	31-79	District meeting, Rochester, N. Y.	April 29–May 2, 1931
J. J. Torok Associate A. I. E. E.	West. Elec. & Mfg. Co., E. Pittsburgh, Pa.	An Experimental Lightning Protector for Insulators	31-9	Winter convention, New York	Jan. 26–30, 1931

rect strokes of negative polarity have been recorded than those of positive polarity, while the majority of induced strokes appear to be positive. The question of polarity is important inasmuch as negative strokes have been observed to have steeper wave fronts, while positive polarity surges attenuate more rapidly.

Extent of System Affected

Flashovers have occurred in the majority of cases on only one phase, but usually involve corresponding insulator assemblies at two or more adjacent towers. Evidences of direct-stroke currents have been observed in as many as five or six towers. On highly insulated ungrounded lines, such as the wood pole line previously mentioned, traveling waves of dangerous magnitude may reach substation equipment and cause flashovers there, since such equipment in general is less highly insulated than the line equipment. Under these conditions, especially good lightning arrester equipment is required at the stations. On well-grounded steel tower lines where flashovers do not occur, severe electrical disturbance usually is limited to a few structures, and any surge propagated over the conductor will be of extremely low magnitude.

Flashovers and Trip-Outs

Flashovers from direct strokes may occur if (1) the stroke terminates on the line conductor; (2) the stroke terminates on a tower of high surge impedance, thus raising the tower potential with reference to the conductor; (3) the stroke terminates on the ground wire between towers and the potential is of sufficient magnitude to cause flashover at that point,

in which case flashover at an adjacent tower is certain to occur.

Experience has shown that direct strokes may occur at towers of low footing resistance without subsequent flashover. Whether or not a trip-out will result when flashovers occur depends upon whether the amplitude and polarity relations of line voltage and current are such as to permit the establishment of a power arc at the time of flashover. That flashovers can occur without causing line trip-outs is definitely shown by records of a lightning surge of 2,500 kv. which did not cause a trip-out but which most certainly did cause a flashover.

Induced surges also may cause insulator flashovers with resultant line trip-outs, especially when direct strokes occur to nearby objects. The likelihood of these surges reaching flashover value, however, is minimized by the installation of conventional overhead ground wires.

Effects of Grounding

Beneficial effects of overhead ground wires have been proved without doubt both by special investigations and operating experiences. Operating experiences have shown also that two ground wires are much more effective than one alone. The effectiveness of ground wire protection depends to some extent upon tower footing resistance; where this is high, special grounding cables or counterpoises can be used effectively to lower the surge impedance of the structures. Counterpoise cables are most effective when extended out radially from the tower foot, but in practical cases are restricted by right-of-way limitations to the two directions along the line. Operating experiences show, however, that flashovers do not always concentrate at towers having high footing resistance.

Line Design

General requirements for good lightning protection are low lines, short spans, low tower footing resistance, and overhead ground wires. The number and position of overhead ground wires will depend upon the conductor configuration and the number of circuits. Spacing between conductors and ground wires must be large in order to prevent flashovers at mid-span.

For effective protection against direct strokes the tower footing resistance should not be more than 4 or 5 ohms. Where this is impractical special overhead ground wire structures, known as diverters, may be installed if the economics of the situation permit.

Protective Devices

Lightning arresters are especially applicable at substations to protect terminal equipment against lightning damage. The principal qualification is that they be placed reasonably close to the equipment they are designed to protect. Arresters also are used on transmission lines where provision cannot be made economically for the installation of overhead ground wires.

In this connection field investigations have shown that arresters of the expulsion type will successfully interrupt dynamic current follow-up. A promising new device now under development consists of a hollow fiber tube with electrodes at either end, wherein the breakdown element is the air contained in the tube. Grading shields have not been found to decrease the number of line outages, but, when properly installed, they do minimize the damage to insulators, line hardware, and conductors, and reduce the amount of cascading required.

Theories of
Lightning Discharge and Traveling Waves

Recent theoretical findings concerning lightning and traveling waves are discussed in this article. When corroborated by field tests, these results furnish information from which a systematic scheme of protection can be established. "Direct-hit" wires above ordinary "sky wires" are suggested and discussed.

LIGHTNING may cause abnormal voltages on power transmission lines in either of two different ways—by direct stroke or by induction. Some understanding of the formation of these surges is necessary before a systematic scheme of protection can be evolved.

According to Fortescue and Conwell the thundercloud consists of small particles of water-vapor, each carrying a minute charge of electricity, free negative charges attaching themselves to the vapor particles. Since the mobility of the resulting charged moisture particles is very small the only way in which a discharge can take place is through ionization. This ionization process results in the formation of a lightning streamer.

Some streamers will never reach the earth because of an insufficient charge in the cloud. This would indicate that lightning disturbances resulting from streamers which do reach the earth will vary somewhat

in severity over a wide range, depending upon the amount of energy which the cloud is capable of discharging. The energy in the streamer itself is mainly potential energy until the earth or a structure is reached, when its potential energy is changed instantly into kinetic energy in the form of a current wave moving at the velocity of light into the earth or structure through the path pioneered by the streamer. Negative reflections pass up the same lightning channel, increasing the discharge current and also the gradient in the cloud. This in turn tends to extend more streamers throughout the cloud until the available

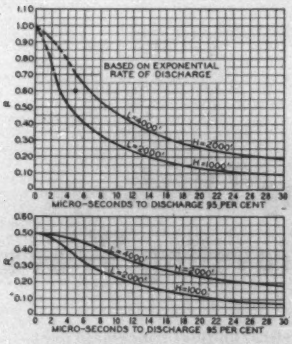


Fig. 1. Values of α for calculating lightning voltages induced on transmission lines (exponential rate of discharge assumed)

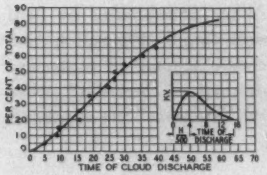


Fig. 2. Duration of cloud discharges determined from cathode-ray oscillograms

energy is decreased below the point necessary to maintain the lightning channel.

Complete data on the limiting value of lightning stroke potentials are not yet available but fairly good approximations for potentials ordinarily encountered may be made. Since voltages may be caused either by direct strokes or by induction, it is of practical importance to be able to estimate the numerical values of these voltages under both conditions.

Direct Strokes

Peek discusses the question of direct lightning strokes from the theoretical aspect and arrives at several interesting conclusions. The chance of a line being struck by a direct bolt increases of course with increasing height of line. On a flat plane without projections, a tower may be hit when the distance from it to the projection of the storm center is less than from four to ten times tower height. This factor is based upon the assumption that the nearest object will be hit and has been called the direct-hit ratio.

Where lines are brought through a right-of-way with nearby trees practically equal in height to the line, the hazard of direct strokes reaching the line should be very small. It has been found that a tree can direct or attract a lightning stroke as readily as can a metal tower because the charging takes place with low current and over a relatively long time. Also it has been found that the chance of any particular tower being struck does not depend upon its footing resistance, but that the resulting voltage on line insulators following a hit does depend almost entirely upon such resistance.

As a rule, a tower is more likely to be struck than the line. When this occurs the resulting voltage between line and tower, or ground wire, or across the line insulator string, is given by the formula

$$V_s = K I R$$

where K is a constant depending upon the tower and ground-wire configuration, I is the tower current (which will be less than the total-stroke current by the current flowing in the ground wire), and R represents the tower footing resistance. Fairly accurate approximations can be made by assuming $K = 0.8$. The importance of keeping the tower footing resistance low is obvious from the above formula if immunity from direct-stroke sparkovers is to be obtained.

As an example, it can be shown that on a line insulated with 14 disk insulator units, a tower resistance of 40 ohms would result in a voltage of 3,200 kv. on a 100,000-ampere direct bolt. In order to keep the voltage below sparkover value of this line the tower resistance must not exceed 20 ohms. For higher discharge currents the tower resistance must be correspondingly lower to prevent the establishment of sparkover voltages.

Induced Surges

When voltages occur by induction their polarity is opposite to that of the cloud source and their numerical values may be calculated by the formula

$$V = G h \alpha$$

where V is the voltage above ground, G is the potential gradient in volts per foot (100,000 is the accepted maximum value), h is the line height in feet, and α is a factor depending upon the duration of cloud discharge and the distribution of bound charge. Values of α calculated on the basis of an exponential rate of cloud discharge may be seen in Fig. 1. Since an instantaneous cloud discharge is impossible, α always will be less than unity. As plotted in Fig. 1 α is the factor to be used in computing maximum potentials at the point of origin while α' is the factor for computing the crest voltage on the resulting traveling wave.

That the distribution of bound charge affects the shape of the traveling wave to a much less extent than does the law of cloud discharge had been determined previously. The bound charge therefore can be assumed to be rectangular without involving any marked departure from the true shape of the traveling wave. Cathode-ray oscillograms are especially useful in determining the shape of traveling waves. If taken reasonably near the source and not badly distorted by sparkovers, losses, or reflections, they give practically the complete life history and characteristics of the stroke. In oscillograms of this nature the time from zero to crest voltage gives a measure of the length of bound charge, while the time from crest to zero on the falling part of the wave is the duration of cloud discharge. In addition the equivalent distance for one-half the time to crest approximates the height of the cloud. These ideas regarding the origin and characteristics of induced surges are concurred in by both Bewley and Peek.

Bewley points out, however, that as the time of cloud discharge increases, both α and α' (Fig. 1) decrease and rapidly approach equality for discharges slower than 10 microsec. He has computed also that for an average line height of 60 ft., and a 3,000-ft. rectangular bound charge (allowing 10 microsec. for the cloud discharge) the maximum voltage for induced traveling waves is somewhat less than 2,000 kv. A similar computation by Peek agrees with this value. It is evident that high-potential induced surges are possible only with very short waves and that for cloud discharges of long duration induced surges become quite harmless.

Peek, in discussing further the relations between traveling waves and cloud characteristics, states that information can best be obtained by cathode-ray oscillograph measurements made in the field. When the waves become distorted, however, the front no longer is of value in obtaining information on cloud height or length of bound charge because the values would be too high. The lengthened tails on such distorted waves indicate a longer duration than actually obtained. A good approximation, however, is that the duration of discharge is twice the time from crest to half voltage on the tail part of the wave. Since due to reflections a wave may persist for a number of loops, only the first loop is of interest for this approximation. Fig. 2 shows the results of a large number of such oscillograms where the crest voltages were higher than 100 kv. and line sparkover did not occur.

When the time and manner of discharge have been determined the lightning discharge current also can be ascertained mathematically. However, since these currents appear quite large (400,000 amperes for a typical case) confirmation by actual field measurements is necessary before final conclusions can be drawn.

General Properties of Traveling Waves

Bewley continues his theoretical study of traveling waves as outlined briefly in the following paragraphs.

The behavior of an n-conductor system having mutual inductance and capacitance between conductors can be formulated by a partial differential equation of the $2n$ order in both time and space derivatives. Although a formal solution for such an equation exists, it is too complicated to be of much use from an engineering point of view. However, solutions for (1) a no-loss system, (2) a completely transposed system, and (3) the steady-state alternating-current condition, are easily obtained.

If a line is free from losses the differential equations of the system are satisfied by pure wave functions. If the line is completely transposed so that every conductor occupies the same relative position as every other conductor, and for the same distance, then the possible average velocities between terminals are reduced to two in number. The conventional method of calculating the steady-state alternating-current behavior of a transmission line by using constants to neutral is a very special case, but is rigorous for a single-circuit, three-phase, completely transposed line.

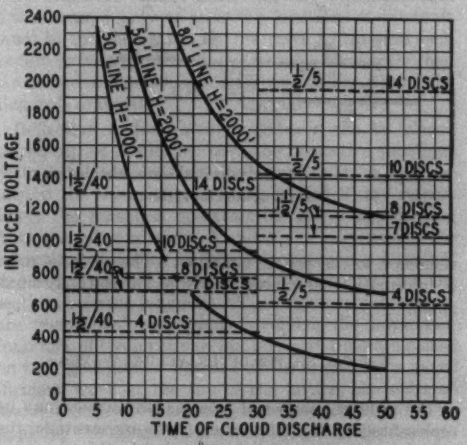


Fig. 3. Induced voltages on 50- and 80-ft. lines for different cloud-discharge durations and two cloud heights

For free traveling waves on a multi-conductor system, the energy is equally divided between the electrostatic and electromagnetic fields. However, when waves moving in the opposite direction pass through one another (as occurs from reflections at transition points) the energy balance is upset so that the energy resides more in one form than in the other. Pure traveling waves, which can occur only in a no-loss circuit, in general have as many possible velocities of propagation as there are conductors in the circuit. When the conductors are overhead wires these velocities all reduce to the velocity of light.

The behavior of traveling waves at general transition points (see Fig. 4) can be determined by a system of simultaneous equations involving the reflection, refraction, and transfer operators of the circuit. By a fortunate coincidence these can be expressed by one or the other of two equations containing only three parameters. In solving for different terminal conditions, therefore, it is necessary merely to tabulate the values of the three parameters for different cases with reference to the proper equation. Thus a large mass of information can be condensed into a relatively small space.

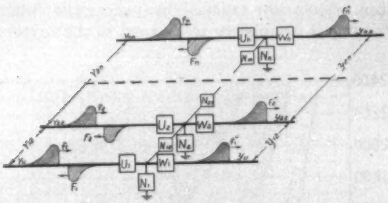


Fig. 4. Incident- and reflected-wave relations on a multi-conductor system

Typical Shapes of Traveling Waves

The principal shapes of most natural waves may be represented by the difference of two exponentials, the actual waves of course being serrated by minor irregularities. The cathode-ray oscillograph has proved its usefulness in investigating this phase of the problem, and during the past few years many oscillograms of natural lightning waves have been obtained under widely varying conditions. These have provided fairly definite information as to the general shape and characteristics of such surges. In calculating the effects of traveling waves, therefore, these characteristics must be kept in mind so that the influence of fronts, tails, and lengths of the waves may be evaluated. Three different methods for calculating waves of arbitrary shape are given by Bewley as follow:

1. Express in operational notation, combine with the function representing the reflection or refraction operator, and solve the resulting operational equations.

2. Consider the wave as made up of a series of infinite rectangular waves, adding the solutions corresponding to each component rectangular wave.

3. Express the wave as the sum of several functions for which the individual solutions are known or can be found, and add these solutions.

Each of these methods is subject to certain advantages and limitations. With the first method the operational equations usually are so complicated that a solution either cannot be obtained at all, or only by the most laborious and complex process. The second method is only an approximation, of course. In a great many cases, however, it is sufficiently accurate and has the advantage of simplicity especially where the incident wave is greatly complicated.

The third method, in which the wave is represented as a sum of functions for which the solutions are known, is quite useful and practicable. By properly compounding a few simple functions almost any desired wave shape can be reproduced with a fair degree of approximation. This process is illustrated for a few typical cases in Fig. 5 where the elementary waves considered are (1) infinite rectangular, (2) simple exponential, (3) uniformly rising front, (4) damped sinusoid, and (5) difference of two exponentials.

Attenuation and Distortion

Bewley continues that it usually is justifiable and convenient to perform traveling-wave calculations on the assumption of no losses, and then to compensate for attenuation by an exponential decrement factor determined experimentally. Corona, it is generally agreed, is the chief cause of attenuation and distortion. It levels off the top and elongates the wave, but its effect is somewhat variable depending upon the weather and other conditions.

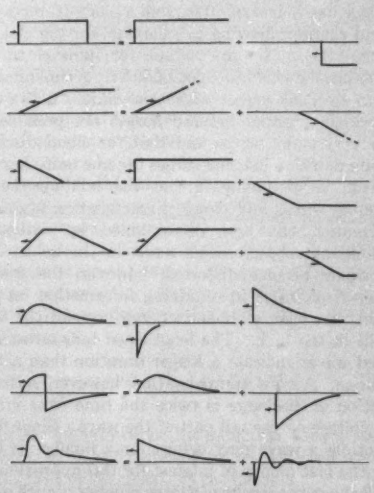


Fig. 5. Separation of complex waves into two simple waves

Effects of line losses are threefold; (1) voltage and current waves are attenuated, (2) wave shapes are distorted with time, and (3) the waves depart from exact similarity, so that the simple linear proportionality

factors (called the surge impedances) and the linear equations cease to hold except as approximations. Skin effect and normal line losses, according to Bewley, are of minor importance and may be neglected in comparison with corona losses.

Brune and Eaton in discussing the theoretical aspects of their line tests state that the very front of the wave suffers the greatest attenuation (becoming less and less steep) the net result being that the entire wave is lengthened and the crest voltage is reduced. This is caused not only by corona, but also by skin effect and series resistance in the line. Attempts to calculate the effect of corona by assuming an equivalent "leakance," however, are stated to be erroneous, since the corona does not establish a conducting path by means of which charges may leak off the line except at voltages near sparkover values.

To clarify somewhat the mechanism of corona, Brune and Eaton explain that usually the area surrounding a conductor becomes conducting only within an envelope of limited radius, and as the voltage rises above the

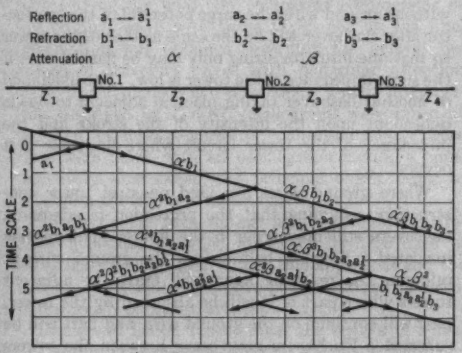


Fig. 6. Typical lattice diagram for computing successive reflections

corona voltage, charges enter this envelope thereby decreasing the voltage on the front of the wave. Such charges will remain in the corona envelope as long as the conductor voltage is high; when it falls the charges return to the conductor thus tending to maintain the high voltage on the tail of the wave. In this exchange of charge between conductor and corona envelope energy is lost, but no charge.

Successive Reflections

In a number of important problems, such as in the theory of ground wire, the effect of short lengths of cable, and trunk lines tapped at short intervals, it is necessary to consider the effects of successive reflections of traveling waves. Difficulty sometimes is experienced in keeping track of such reflections where numerous reflecting points exist. To solve this difficulty lattice diagrams have been devised which show at a glance the position and direction of motion of every incident, reflected, and refracted wave on the system at every instant of time. In Fig. 6 a typical lattice diagram has been set up for a line containing three reflection points. These reflection points may consist of any combination of impedances in series with the line or shunted to ground. The circuits between these points may consist either of open lines or cables, and may have different surge impedances, velocities of wave propagation, and attenuation factors.

To construct such a lattice for any particular case it is necessary only to scale the junctions at intervals equal to the time taken by the wave to traverse each section between junctions. A suitable time scale then can be chosen (shown as the ordinate in Fig. 6) and the diagonals drawn in.

Reflection and refraction operators can be placed at the top of the lattice over the respective junctions with suitable directional indicators. These may be seen at the top of Fig. 6 where a and a' are respectively the reflection operators for waves approaching from the left and right, b and b' are respectively the refraction operators for waves approaching from left and right; α and β are attenuation factors for the sections between junctions. These operators, of course, are operational expressions involving the impedance functions of the junctions, but no restrictions are placed on their generality. Starting at the origin of the initial incident wave at the top of the lattice, the reflected and refracted waves at each junction can be obtained by applying the operators of that junction to the incident wave arriving there, then proceeding until the lattice has been completed. In these lattice diagrams it will be observed that:

1. All waves travel "down-hill."
2. The position of any wave at any time is determined from the vertical time scale at the left of the lattice.
3. The total potential at any point at any instant of time is the superposition of all the waves which have arrived at that point up to that instant of time, displaced in position from each other by intervals equal to the instants of their time of arrival.
4. The previous history of any wave is easily traced.
5. The effect of attenuation is included.
6. If it is desired to carry the computations to a point where it is not practical to place the various operators directly on the lattice itself, then

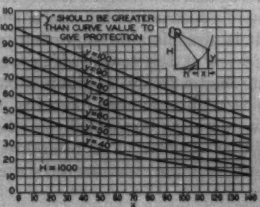


Fig. 7. Minimum ground wire heights (y) to shield line conductors against direct strokes from clouds 1,000 ft. above

the arms may be numbered and the operational expressions tabulated in a suitable form.

Dowell has used this method in analyzing the results of some of his investigations with artificial lightning impulses applied to typical sections of lines. These are treated in another part of this symposium.

Overhead Ground Wires

To protect line conductors from direct hits the ground wire or wires should be at a sufficient distance above the line wires to "attract" the lightning. Peek has found that the shielding effect of ground wires depends not only upon their vertical height but also upon the horizontal distance between their projections and those of the line wires. Fig. 7 shows minimum values for the ground-wire heights required to protect the line wire against direct hits from a cloud 1,000 ft. above the earth. The respective heights for the line and ground wires are represented by h and y, and the horizontal distance between by x.

While this position for the ground wire may shield the line wire from the initial hit, it does not protect against side flashes or sparkovers from a struck ground wire to a line wire, where the hit takes place at some distance from a tower.

Hazards due to direct hits of this nature can be reduced by special provision in ground-wire design and tower spacing, but usually these are considered unnecessary since the chance of a hit between towers is small.

Even with ground wires installed, however, immunity from outages due to direct hits can be approached only with low tower footing resistance to maintain low tower potentials, and with heavy line insulation. In some cases in addition to the overhead ground wires with which lines now usually are equipped, "direct-stroke" wires strung above the ground wires may be necessary to prevent flashovers from midspan hits. The advantageous effect of short span construction can be simulated by supporting the ground wire not only from the main towers, but also from intermediate towers interposed between the main towers. Low-footing resistance usually can be obtained by means of buried (counterpoise) wires connected to the tower legs. The adoption of such an expedient will be governed, however, largely by cost considerations.

In rocky and mountainous country where it is difficult to obtain low tower footing resistance special ground-wire construction or line shielding may be necessary. It is possible also to prevent outages by some form of device at the tower which would permit lightning to discharge freely to ground, but which would prevent power current from following. One such device which is operating successfully is the fused grading shield. Other devices have been brought out, but still are largely in the experimental stage.

Formation of line surges due to lightning strokes is analyzed by Fortescue and Conwell in accordance with the type of transmission construction used. Their two classifications are (1) wood pole lines and steel tower lines not equipped with ground wires, and (2) steel tower lines equipped with ground wires.

Considering first wood pole lines unprotected by ground wires or spill-over gaps, the potential attained by a surge before the structure breaks down may be very high. When the structure flashes over, the potential is reduced quickly to a value which depends upon the surge impedance of the conductor and of the wood poles and ground. Some simple calculations using accepted formulas and constants show that a stroke which would deliver a 15,000-kv. surge on a single line conductor will appear at 77 per cent of this value on all three line conductors when all three are struck. Under such conditions flashover to ground will occur immediately, but a potential of about 30 per cent of the original surge will still exist. In the case of steel towers without ground wires the surge potential of the conductor after flashover will be the same as that of the tower so that one insulator string only may be flashed over if the surge impedance of the tower is low. The likelihood of another flashover taking place at adjacent towers is dependent upon the intensity of the stroke and the impedance of the tower circuit where flashover first occurs.

Where ground wires are used on steel tower construction, assuming that the protection is adequate, flashovers still may occur if the line is inadequately insulated. When a bolt strikes the ground wire at midspan the resulting surge will travel to adjacent towers where part of it will be absorbed by the tower, part will continue on the ground wire, and part will be reflected. Flashovers may occur between the towers and one or more conductors, so that towers, ground wires, and affected conductors will assume the same potential. Flashover also may take place at midspan between conductors and ground wire; the conductor potential then will be of sufficient magnitude to cause an additional flashover at an adjacent tower.

In a well protected, well insulated line a stroke to the ground wire in midspan or to a tower is quickly reduced by reflections from adjacent towers and becomes of very small magnitude three spans distant from the point hit. Calculations indicate that where tower footing resistance is low, insulator flashover is not likely to occur. In all cases where flashovers do not occur either at midspan or at towers, potentials induced on the conductors by coupling will become negligible beyond the region of the disturbance. In such cases no surge will be propagated over the line to terminal apparatus and the line will continue to operate unaffected by the lightning stroke.

Field Tests with Artificial Lightning

High-voltage impulses simulating lightning surges can be impressed on a line at will, and now provide the most convenient means for studying the characteristics of such waves. Corona is found to be the greatest cause of wave attenuation and distortion; to a lesser extent, skin effect.

IN THE first class of field investigation described, high-voltage impulses were impressed upon the line and cathode-ray oscillograms taken at different points along the line. By comparing oscillograms of the original wave with those taken out on the line, information was obtained regarding the general behavior of traveling waves with particular attention given to attenuation and distortion. In the investigation described by Dowell, oscillograms were taken at the point of impulse-generator connection only. These tests were made with an oscillograph having a comparatively slow sweep, the principal object being to determine the effects of reflections.

To obtain the high-voltage surges, a lightning impulse generator designed especially for this class of investigations was used. Both this apparatus and the cathode-ray oscillograph have been described in detail in previously published articles.

Brune and Eaton report upon the results of a test of the first type mentioned which was made jointly by the General Electric Company and the Consumers Power Company (Mich.) on the Croton Dam-Grand Rapids 75-kv. line of the latter company. Line data and other features of these experiments are given in Table II. Because previous sphere-gap tests showed that the rate of attenuation is affected by voltage, polarity, and distribution of the charge over one or more conductors, test wave shapes were chosen to accentuate these features.

Factors Affecting Wave Propagation

A group of typical cathode-ray oscillograms replotted to uniform time and voltage scales is shown in Fig. 8. It may be noted that attenuation is much more rapid above corona voltage than below it (the calculated critical corona voltages for this line being 85 and 125 kv. for surges on one and on three parallel conductors, respectively).

These waves support the theory that in the mechanism of corona, as previously outlined, (1) the area surrounding a conductor becomes conducting only within an envelope of limited radius; (2) when the voltage rises above the corona voltage, charges enter the envelope and remain there until the conductor voltage falls, returning then to the conductor and thus holding up and flattening out the tail of the wave. The process can be likened to the discharge of one condenser into another through a resistance, the difference being that on a transmission line the quantities are distributed rather than lumped, and are variable depending upon the voltage.

It may be noted, however, that other factors besides corona appear to affect the propagation of the surges. This is brought out clearly in those oscillograms where the crest voltage is below the critical corona value. Such waves exhibit changes in form which might be caused by line resistance, the general effect observed being a continuous attenuation of the front of the wave, a reduction in crest voltage, and lengthening of the wave tail. This is accounted for by the variable character of the line resistance due to skin effect as explained in another article of this group.

Lewis and Foust attribute the flattening of the wave front and lengthening of the tail to the lower velocity of propagation for the high-voltage portion of the wave, but that such a point of view must not be accepted finally as an explanation of the mechanism of surge propagation without a closer examination than has yet been given. These authors state further that the influences of corona and polarity upon surge propagation have been shown to be great and that both probably are determining factors. Conditions of relative energy loss on the front, crest, and tail of the wave, however, are said to be but little understood, the shift of energy relations within the wave possibly accounting for wave changes which have been demonstrated.

Attenuation

Attenuation curves for several tests showing maximum voltage against miles of wave travel are shown in Fig. 9 (Brune and Eaton). The effect of polarity upon attenuation is evident in these curves at once, the positive surges being attenuated more rapidly than the negative surges, especially by corona. In comparing waves *I* and *J* with waves *A* and *B*, it may be noted also that short waves are attenuated more rapidly than are long waves.

To draw a comparison in attenuation between waves on one and on three parallel conductors, respectively, reference is made to curves *C* and *I* (which have approximately the same length at a voltage of about 600 kv.). It may be seen readily that surge *C* attenuates more slowly than surge *I*; the same comparison may be drawn between surges *D* and *J*. It seems obvious, therefore, that a surge on three conductors will attenuate more slowly than a corresponding surge on one conductor. This is in accord with the fact that

where the same voltage is applied to three parallel conductors the voltage gradient will be less than around a single conductor. Therefore, the effect of corona (which is considered the greatest single contributing factor) will be less for three conductors than for one.

Reflections

The experiments described by Dowell were made on the 132-kv. Philo-Canton line of the Ohio Power Company (see Table II). The oscillograph in this case was coupled to the line at the point of connection of the lightning impulse generator. The voltage measured is the sum of the incident and reflected waves, the two components being entirely different in magnitude and shape. Crest voltages of the applied waves were obtained by sphere-gap measurements, and the voltages of successive reflections by comparative deflections on the oscillograms. All waves in these tests were applied to a single line either grounded or open-circuited at the far end. According to Dowell, if the applied wave

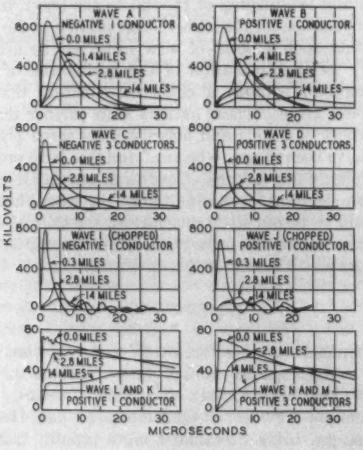


Fig. 8. Typical oscillograms replotted to uniform scales to illustrate change in wave shape with travel along the line

is of the order of two or more times the length of the transmission line, successive reflections are superposed on one another and the individual waves must be segregated before attenuation constants can be obtained. This segregation was facilitated by use of the lattice diagrams described by Bewley in another part of this symposium.

Reflection and refraction operators were derived mathematically for the existing line and terminal conditions. When applied to the function of time representing an incident wave, these operators give respectively the differential equations, the solutions of which are the reflected and refracted waves. This mathematical work was facilitated by the use of Heaviside's operational calculus. Attenuation constants were determined by comparing the calculated values with the oscillogram measurements. This method of attack seems especially applicable to cases wherein the wave of the applied impulse is long enough to permit a

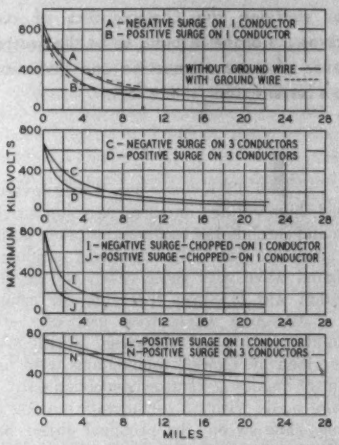

A – NEGATIVE SURGE ON 1 CONDUCTOR
B – POSITIVE SURGE ON 1 CONDUCTOR
WITHOUT GROUND WIRE
WITH GROUND WIRE
C – NEGATIVE SURGE ON 3 CONDUCTORS
D – POSITIVE SURGE ON 3 CONDUCTORS
I – NEGATIVE SURGE – CHOPPED – ON 1 CONDUCTOR
J – POSITIVE SURGE – CHOPPED – ON 1 CONDUCTOR
L – POSITIVE SURGE ON 1 CONDUCTOR
N – POSITIVE SURGE ON 3 CONDUCTORS
MAXIMUM KILOVOLTS
MILES

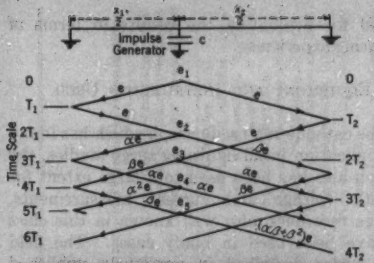
Fig. 9. Reduction in crest voltage of typical traveling waves

reflection to return to the point of measurement before the original wave has completely passed that point.

A typical lattice diagram for a typical line condition with an oscillogram taken at the lightning generator under the same condition may be seen in Fig. 10. The various crests in the oscillogram show definitely the effects of successive reflections especially at the fifth wave crest where reflections from both ends of the line are superposed.

Discussing attenuation on the basis of his results, Dowell agrees that the principal causes of wave attenuation and distortion are corona and, to a lesser extent, skin effect. However, he states that artificial lightning waves may attenuate considerably without an appreciable change in shape, other than some slowing down of the crest. From these findings it is thought permissible to treat such traveling waves as though the line were distortionless, in which case the attenuation is accounted for by a simple exponential decrement factor. Waves calculated under these conditions check quite closely with oscillogram measurements as may be seen from Fig. 11.

Dowell states further that while the segregation of



Typical comparisons between calculated waves and actual measurements

Fig. 10. (Left) Lattice diagram with oscillogram taken at point C for line condition shown. Note peak at fifth wave crest where two reflections are superposed (e_5 in diagram)

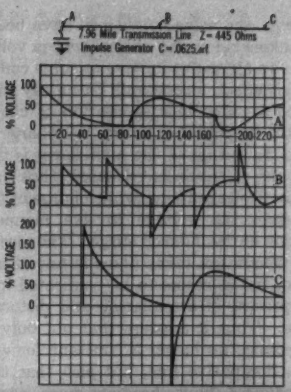
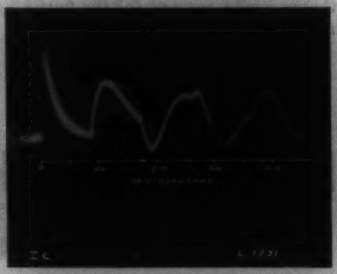


Fig. 11. (Right) Voltage-time relations for traveling wave on line open at one end, (above) computed curves, (below) oscillogram at point A



the attenuation from successive reflections is a long and laborious process subject to errors both in the mathematical and oscillographic work, the calculations demonstrate once more that traveling waves on transmission lines may be computed with excellent engineering accuracy by treating the line as distortionless.

Induced Voltages in Parallel Conductors

The theory of induced surges in parallel conductors developed by K. W. Wagner for the non-dissipative line, leads to a set of simultaneous linear equations expressing surge voltage on any conductor in terms of the surge currents on all the conductors. The usual convention of regarding all voltages as being composed of two traveling waves proceeding in opposite directions is observed. Because of the linear relationships in these equations an induced surge will have exactly the same wave shape as the inducing surge. An isolated conductor will have a potential due to its position in the field, but no current along the conductor.

Sphere-gap measurements of induced voltages made in 1929, however, showed that the ratio of induced to inducing voltages increased as the surge proceeded along the line. Since attenuation was also in evidence it followed that the theory of the non-dissipative line would not hold accurately.

Further light is thrown upon this phenomenon by oscillograms obtained by Brune and Eaton, a selection of which appears in replotted form in Fig. 12. In these oscillograms it may be seen that the wave shapes of induced and inducing surges differ widely. For both positive and negative waves the voltage of induced surge is lower at the beginning and higher later on than that which would be due to the field of the inducing surge alone, while the negative induced surge is actually of opposite polarity at the beginning. This peculiarity in the induced wave cannot be attributed to corona

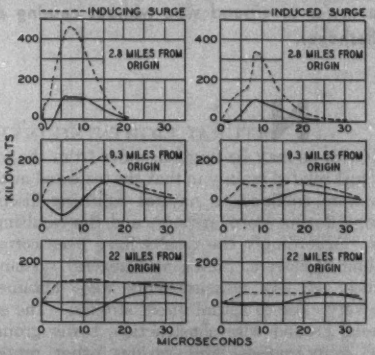


Fig. 12. Replot of induced and inducing surges on free conductor for both negative (left) and positive (right) inducing impulses

effects; the same conditions have been found to exist on surges below the critical corona voltage.

In an attempt to arrive at some conclusion in regard to this effect, Brune and Eaton say that there appears to be a continuous separation of charge taking place within the induced surge. A charge having polarity opposite to that of the main surge is thought to collect in front of the induced surge, thus decreasing the resultant voltage there, while charge of the same polarity increases the voltage in like manner in the latter portion of the induced surge. The mechanism by which this separation takes place is not at all clearly understood, but it seems to be connected in some way with the process of attenuation and distortion of the main wave. Thus it appears that not only is the self-surge impedance no longer a constant for wave propagation on a dissipative line, but also that the mutual surge impedances have become more complicated. This theory would account for the flattening in wave crest noted in Fig. 8, waves *C*, *D*, and *N*.

Field Tests With Natural Lightning

Although lightning surges of as high as 5,000 kv. have been recorded, only about ten per cent of these have crest voltages of more than seven times normal line voltage. One important result of recent investigations is the proof that a direct stroke can occur to a tower or ground wire without causing a flashover.

NATURAL LIGHTNING INVESTIGATIONS, as may be implied, differ from the experiments just related mainly in that the tests and measurements were confined to natural lightning discharges occurring during storm periods, and the resulting line surges. Accordingly the results have been correlated with line flashovers, faults, and general system performance. A few measurements were obtained at points very close to actual direct strokes. The effects of special ground wire construction, tower grounding cables, counterpoises, and various other protective measures were investigated.

Inasmuch as these investigations were conducted for the most part with the lines in operation an opportunity was afforded for evaluating the results in terms of actual operating experience.

Test Equipment and Instruments Used

Besides the cathode-ray oscillograph which has found universal application in all lightning surge studies, the klydonograph also has been used to a large extent for making both voltage and current measurements. Surge-voltage recorders, also well known in this class of work, have been used in many cases. The field intensity recorder described in previously published articles also has found some application. Three new devices, developed especially for this sort of investigation and used in some of the more recent tests, are:

1. Direct-stroke recorder.

This instrument consists essentially of a small klydonograph with timing accessories omitted, and is built into an ordinary telephone receiver. It usually is coupled directly to the transmission-line tower through a resistance potentiometer. (See Fig. 13)

2. Surge or flashover indicator.

This is a small device which can be applied to each insulator assembly on a tower and is so designed that an indication visible to a ground patrolman will show after a flashover on that assembly has occurred.

3. Storm-severity meter.

This consists essentially of a roll-film box camera containing a special glow tube, the tube being connected between a 30-ft. vertical antenna and ground. Collapse of electric charges collecting on the antenna during storms causes the tube to glow and record a spot on the film; thus the intensity or degree of darkness of this spot is an indicated function of the number of charges on the antenna and their magnitude.

The lines on which these investigations have been carried out are indicated in Table II (see also Fig. 15). Line construction data are given with special features noted; instruments used in each case are listed to give some indication of the scope of each investigation. Unusual features of each investigation are noted also.

The results although sometimes difficult to interpret nevertheless reveal many interesting aspects of the lightning situation and the line protection problem. Wherever possible attempts have been made to correlate system disturbances directly with either direct strokes or induced surges. The inconsistencies which still exist are due partly to an incomplete understanding of the fundamental nature and behavior of lightning, and partly to the widely varying nature of the lightning discharge itself.

Direct and Induced Strokes

That effective measures for protection may be adopted, it is necessary first to distinguish between direct and induced strokes, the relative magnitudes of their potentials, and the frequency of occurrence and other characteristics, and then to evaluate these in the light of system performance. That direct strokes to line conductors nearly always cause flashovers and trip-outs, is quite generally agreed; and that direct strokes to ground wires or towers often do also. In-

TABLE II—Line and Instrument Data with Special Features of Field Investigations

Name and location	Operated by	Line Data: Operating kv.	Line Data: Miles of line under test	Line Data: Structures	Line Data: No. circuits	Line Data: Configuration	Other features	Instruments used	Special features of investigations
Croton Dam-Grand Rapids (Michigan)	Consumers Pwr. Co.	70	45	Steel tower	1	Vert.	1. One ground wire throughout	1. 1,500,000-volt impulse generator 2. Cathode-ray oscillographs	1. Characteristics of surges induced in parallel conductors investigated. 2. Effects of tower counterpoises studied.
Philo-Canton (central Ohio)	*Ohio Pwr. Co.	132	73	Steel tower	2	Vert.	1. One overhead ground wire throughout 2. Two lightning arresters installed on line	1. Surge voltage recorders 2. Cathode-ray oscillographs 3. Direct stroke recorders 4. Flashover indicators 5. 1,000,000-volt impulse generator	1. Two investigations made: (1) attenuation and reflection experiments with artificial lightning surges; (2) a study of natural lightning disturbances. 2. Surge voltage recorders installed on two 132-kv. lightning arresters. 3. "Double-sweep" cathode-ray oscillograph used (see Fig. 14).
Roseland-Siegfried & Roseland - Plymouth (central and southern N. J.)	Pub. Serv. Elec. & Gas Co.	220	6	Steel tower	1	Horiz.	1. Two ground wires throughout 2. Arcing rings on all insulator strings	1. Portable 1,000,000-volt "lightning" generator 2. Cathode-ray oscillographs 3. Klydonographs	1. Tests made while lines were under construction. 2. Flashovers related to ground wire protection and tower footing resistance. 3. Lightning currents measured by klydonographs installed directly in parallel with power footings.
Wallenpaupack-Siegfried (eastern Pa.)	Penn Pwr. & Lt. Co.	220	65	Steel tower	1	Horiz.	1. About 37% of line equipped with two overhead ground wires 2. Counterpoises on 2.5-mi. section 3. 80 towers fitted with grounding cables 4. 3.5-mi. section with overhead diverting cables	1. Cathode-ray oscillographs 2. Flashover indicators 3. Surge voltage recorders 4. Direct stroke recorders 5. Magnetic oscillographs and high-speed recorders 6. Field-intensity recorders 7. Rate-of-change-of-field recorders 8. Storm severity meters	1. Fast- and slow-sweep cathode-ray oscillographs used. 2. Antennas installed for measuring induced voltages. 3. Two lightning arrester installations 4. Effects of direct-stroke diverters and special tower grounding investigated.
Deepwater - Pleasantville (southern N. J.)	*Atlantic City Elec. Co.	132	30	Steel tower	2	Vert.	1. Two ground wires in vertical plane through center of tower over entire length of line 2. Arcing rings at both ends of insulator strings	1. Direct-stroke recorders 2. Surge-voltage recorders 3. Flashover indicators	1. Study of induced and direct strokes made with particular attention to resulting flashovers and outages. 2. Line designed for 132 kv., but operated at 66 kv. during entire test period.
Turner-Logan, Glen Lynn-Roanoke, & Turner-Cabin Creek (western parts of Va. & W. Va.)	*Appalachian Elec. Pwr. Co.	132	59	Steel tower	2	Vert.	1. One ground wire throughout 2. Conductors on two sides of towers in reverse-phase order 3. Grading shields and horns on all insulator strings 4. Tower footing resistances high	1. Klydonographs 2. Cathode-ray oscillographs 3. Direct stroke recorders	1. Four-year study of natural lightning disturbances. 2. Data were obtained on one line both before and after the installation of a ground wire. 3. Klydonographs installed on lightning arresters at substations. 4. Line flashovers correlated with tower elevation.
Camden-Magnolia (southern Arkansas)	Ark. Pwr. & Lt. Co.	110	28	Wood pole	1	Horiz.	1. Fused horn-gaps from each phase to ground at 1-mi. intervals except in 9-mi. section near oscillograph station	1. Cathode-ray oscillographs 2. Klydonographs	1. Behavior of lightning surges on a highly insulated wood pole line observed. 2. A new arrester of the air-expulsion type tried out.

*Subsidiaries of American Gas & El. Co.

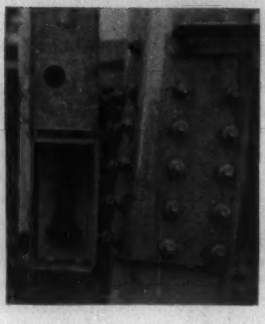


Fig. 13. Direct-stroke recorder installed at base of tower

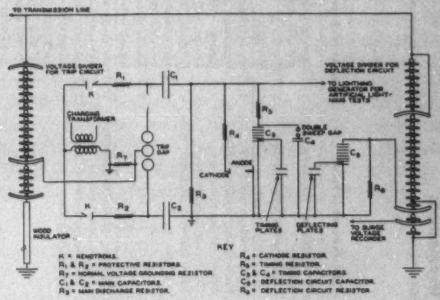


Fig. 14. Circuit diagram for a "double-sweep" cathode-ray oscillograph

duced surges, either from cloud discharges unaccompanied by stroke to earth, or from direct strokes to nearby objects, may in some cases be sufficiently high to cause flashovers and line trip-outs. The probability of induced voltages causing line outages is greatly reduced by overhead ground wires, and also depends to a large extent upon tower footing resistance and line insulation.

Bell and Price, in reporting the results of extensive investigations pursued on the 220-kv. transmission system of the Pennsylvania Power & Light Company, state that direct strokes usually contact only one object (ground wire, power conductor, or tower top) and do not fork to other objects (power conductors for instance) in the same vicinity. They also state that voltages induced in the conductors by the collapse of cloud fields do not appear to endanger service over circuits as highly insulated as the lines in question. In their investigation an attempt was made to determine the approximate magnitude of induced surges by measuring the voltage induced in a 100-ft. antenna installed near the line, but not coupled to it. A potential of from 2,700 to 3,150 kv. was measured on this antenna, but the corresponding voltage induced in the line conductor was only about 350 kv. In no case could extremely high voltages measured on the transmission line be correlated with those measured on the antenna.

During this same investigation an oscillogram was obtained of a direct stroke of negative polarity which occurred not more than 500 ft. from the lightning laboratory and which caused a trip-out and single-phase fault. This oscillogram is shown in Fig. 16. As may be noted, the voltage rise was rather gradual for the first 3.5 microsec., but was quite rapid during the next 2 microsec., until the insulator flashed over on the crest of the wave at a potential of more than 2,760-kv., the maximum range of the oscillograph.

Another interesting record of a direct stroke is that obtained by Gross and Cox. (Fig. 17.) This represents a klydonograph record, simultaneous records being obtained by both the direct-stroke recorders and cathode-ray oscillograph. The line (Turner-Logan) tripped out three times within 20 minutes during this storm, but the only flashover which could be located by inspection after the storm, was on the top phase of the tower adjacent to that at which the klydonogram was obtained.

Two cases are reported by Sporn and Lloyd wherein trees were struck at points quite near the line. In one case two trees respectively 500 and 1,500 ft. from the line were struck. The nearest surge-voltage recorder (more than a mile away) indicated two highly damped surges of −4.8 and +2.4 times normal voltage, but it was impossible to correlate either stroke with a line trip-out or even a flashover. By a peculiar coincidence another tree at this same point had been struck previously. This tree was 360 ft. from the line and near the 500-ft. tree mentioned in the other case. At that time the surge recorder (located at an adjacent tower) indicated a positive maximum voltage of 2,100 kv. A trip-out occurred apparently caused by the high voltage induced from the direct stroke to the tree. These two cases well illustrate some of the inconsistencies encountered.

Lewis and Foust comment on the question of direct and induced strokes as follows:

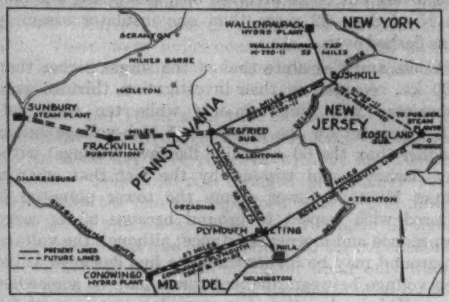
"Apparently there is evidence to the effect that direct strokes play an important part in transmission flashovers and outages. There is a great deal of evidence that induced strokes also are highly important. There is insufficient evidence at the present time to evaluate more exactly these two types of strokes."

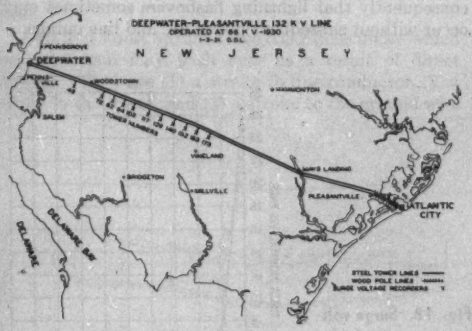
Crest Values of Lightning Surges

As might be expected the crest values of lightning voltages and currents are subject to many variations also. Bell and Price report a maximum voltage well above 3,000 kv. (see Fig. 16) measured at a point not more than 500 ft. from the stroke. Currents from less than 40,000 to about 260,000 amperes are indicated in their report.

Voltage measurements from a 4-year study are plotted by Gross and Cox as shown in Fig. 18. Volt-

ages of surges due to switching also are shown in this diagram. The maximum lightning voltage recorded was about 26 times normal, or 2,800 kv. It may be noted that only 10 per cent of the surges were of more





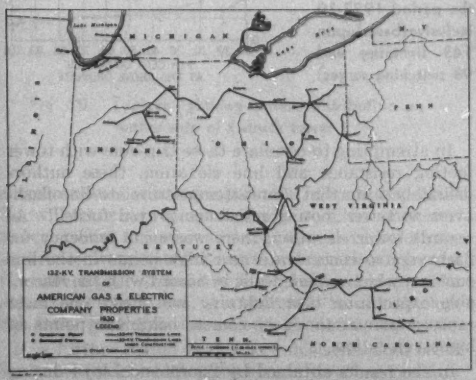


Fig. 15. Some of the lines upon which lightning investigations of the past few years have been concentrated

than seven times normal line voltage. It has been computed also that the lines involved in this investigation (Appalachian Electric Power Company) are subject to 4.6 lightning voltages of 15 times normal per 100 mi. of line per year. Compared to other published data this would show that the lines in this territory are subjected to lightning disturbances of greater than average severity.

In the same investigation similar results were obtained for lightning voltages appearing at substations. In this case the highest lightning voltage recorded was only twelve times normal while only 4.5 per cent were more than seven times normal. This reduction is attributed to the lightning arrester protection installed at substations and also to the number of paths into which an incoming surge can be dissipated.

Sporn and Lloyd report a maximum lightning voltage obtained (Philo-Canton line—1930) by surge recorders of only 6.5 times normal (700 kv.). The low severity of lightning storms during that year in that section of the country is believed to be the reason for the absence of higher voltage measurements. Discharge currents of from 40,000 to 670,000 amperes were indicated, however, (by adding the tower currents), the current distribution for a typical case being shown in Fig. 19. These values are subject to a certain amount of error because of the fact that all currents may not have been recorded simultaneously. Reflections at points of changing surge impedance also would affect the measurements.

Lewis and Foust have plotted (see Fig. 20) the results of lightning voltage as measured by surge-voltage recorders based on a study of 678 lightning surges occurring on fourteen systems during the years 1926-1930 inclusive. Voltages due to switching are shown also, based upon 724 surges occurring during the years 1927-1930 inclusive on practically the same systems from which the lightning data were taken. These curves are in close agreement with those obtained by Gross and Cox.

All of the results mentioned so far have been concerned with lines having steel supporting structures.

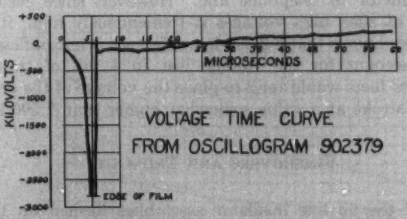


Fig. 16. Oscillogram of a direct stroke taken about 500 ft. from point of stroke and 125 ft. from insulator flashover; flashover occurred also at an adjacent tower and was followed by a line trip-out

Fig. 17. Klydonograph record of a lightning surge

Negative surges are indicated on ground wire and two top conductors; positive surges are in evidence on all line conductors. A simultaneous cathode-ray oscillogram showed the disturbance to be oscillatory. (Important details of klydonograph records are unavoidably lost in reproduction.)

Much higher voltages due to lightning have been reported by Pittman and Torok in their tests on the Camden-Magnolia (Ark.) 110-kv. wood-pole line. On this line pole-grounding wires are installed only on guyed structures which normally are about one mile apart. The maximum voltage recorded in the investigation was approximately 5,000 kv. measured at a point about 4 mi. from the point of stroke (see Fig. 21). The indicated rate of potential rise is about 4,000 kv. per microsec. These values contrast sharply with the maximum reported on steel-tower lines. It appears quite obvious that the voltage of the discharge if measured at the point of incidence would have been much higher than the voltage measured 4 mi. distant, although the actual maximum value is a matter of interesting speculation.

An examination of the surroundings near the point of discharge of this bolt showed that an arc had been established from a line conductor to a telephone wire crossing 22 ft. below the line. In addition both 50-ft. poles on the H-frame supporting structure adjacent to the telephone line crossing were splintered. Allowing 350 kv. per ft. as the breakdown strength of air, a potential of 7,500 kv. would be required to flash from conductor to telephone line. However, since corona loss at such high voltages is tremendously high, it is quite obvious that a 2,500-kv. difference is not sufficient to account for the voltage lost in 4 mi. of travel. These facts would tend to place the voltage of the original stroke at a value somewhat higher than 7,500 kv.

Flashovers and Trip-Outs

Of the 65 line insulator assemblies flashed on the 220-kv. Wallenpaupack-Siegfried line, Bell and Price report that 71 per cent showed glaze burns characteristic of dynamic arcs. Of 38 flashover indicator operations, 29 (76 per cent) were associated with marked insulator assemblies. Most of these flashovers occurred on phase conductors occupying the outer positions on the towers. Some 24 trip-outs were associated with the 65 flashovers most of these being accompanied by single-phase faults. Their results show in addition that 32 flashovers out of 36 involved only one phase, but that in 15 of these 32 more than one insulator assembly was flashed over.

Gross and Cox state that of the surges higher than 600 kv. recorded in their investigation, thirteen were associated with line trip-outs while ten were not. They account for the existence of high-voltage surges (higher than the 60-cycle line flashover voltage) without flashover and trip-out by the fact that when a direct hit to a tower occurs the tower potential is altered with respect to ground because of its surge impedance and footing resistance; although the voltage to ground may be higher than the line flashover value the voltage between line and tower may be somewhat less. This explanation, however, does not account for the absence of trip-outs in all cases, and it is believed consequently that lightning flashovers sometimes may occur without subsequent power arc and line outage.

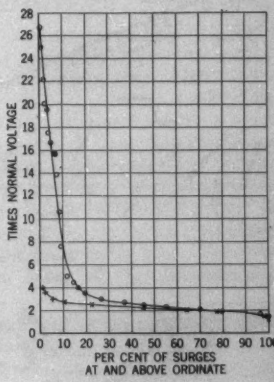


Fig. 18. Surge voltages reported by Gross and Cox for the period 1927-30 inclusive (based upon 143 lightning and 98 switching surges)

In attempting to correlate these trip-outs with tower footing resistance and line elevation, these authors definitely state that, "an attempt to relate line flashovers to tower footing resistance proved futile." As regards tower elevation, there was some tendency for flashovers to concentrate near high points in the line contour, which experience is in accord with the reasonable expectation that lightning will strike the most exposed points; these, of course, being the points of highest elevation.

In the results obtained by Sporn and Lloyd during 1930 on the Deepwater-Pleasantville 132-kv. line, twelve direct strokes were recorded, only three of which could have resulted possibly in a trip-out, while on the 30-mi. section of the Philo-Canton line thirteen

direct strokes were recorded, only one of which possibly could have produced a trip-out. Of a total of 107 surges recorded in Ohio only 33 per cent were due to lightning, 60 per cent being due to switching. Notwithstanding the many surges recorded, only four trip-outs occurred, three of which involved both circuits. There were indications, however, that flashovers had occurred in some cases where trip-outs had not.

Pittman and Torok state that on the wood pole line upon which their investigations were made, voltages as high as 2,000 kv. were recorded without any switch operation. This was not thought particularly surprising since the line was equipped with several drain points set to operate at about that voltage. General experiences on this line have pointed to the conclusions that voltages of a harmful character occur only when direct strokes or their branches terminate on the conductors, and that trip-outs on ungrounded wood pole construction usually result from phase-to-phase flashovers.

Lewis and Foust outline three conditions under which line insulation may flash over as a result of direct strokes. They are (1) a stroke to line conductor, (2) a stroke to the tower, and (3) a stroke to the ground wire

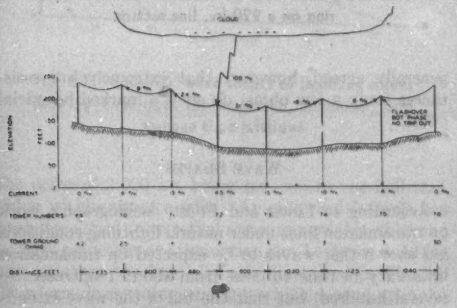


Fig. 19. Typical lightning current distribution on either side of a struck tower

between towers where the potential is such that flashover will occur between ground wire and line conductor. Direct strokes to line conductors appear to be of rare occurrence where steel towers and overhead ground wires are used. Where insulator flashover does occur under these conditions, it apparently results through high tower potentials caused by high footing resistance.

It is further stated that where flashover does occur from tower to conductor the spread to other insulator assemblies on the same tower may be prevented by the resulting reduced impedance between tower and ground. Experience has shown also that a flashover is not necessarily followed by a line trip-out. A permanent arc is not set up because the power voltage to ground and conductor current do not have sufficient amplitude and proper polarity relations to establish it.

Extent of System Affected

The extent to which a transmission system may be affected by lightning discharges appears to depend mainly upon line design and insulation; also upon whether or not flashover occurs at or near the point of incidence. On steel-tower lines where flashover occurs, experience has shown that the disturbance is limited to five or six adjacent towers, flashover in most cases occurring on one phase only, but in many cases on two insulator assemblies at adjacent towers.

Fortescue and Conwell state that if a tower or ground wire is struck and no flashover results, severe electrical disturbance is limited to a few structures, and any surge propagated over a conductor will be of extremely low magnitude. They also agree that disturbances on tower and ground-wire systems usually are limited to approximately six spans, where tower footing resistances are low. Potentials induced on the conductor arising from such surges on the ground wires become nil beyond the region of the disturbance. Thus no surge on the conductor can be propagated beyond this region unless flashover takes place.

In addition to the foregoing, Fortescue and Conwell discuss in some detail the effect of line construction on surges propagated over the lines to substations. It is finally concluded that ordinarily with only one type of construction, namely, ungrounded wood pole, will the potentials be sufficiently high to endanger substation equipment. Pittman and Torok's results agree with the fourth case just described in that voltages of high magnitude may be transmitted for several miles along highly insulated transmission lines and thus appear at terminal apparatus. This is true especially when direct strokes or their branches terminate on line conductors.

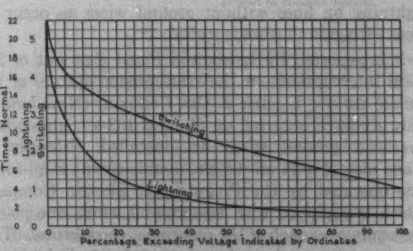


Fig. 20. Surge voltage curves compiled by Lewis and Foust based upon data from fourteen systems for the years 1926-30 inclusive

"That a direct stroke could occur to the line without producing a trip-out" is said by Sporn and Lloyd to be one of the outstanding determinations of the 1930 lightning investigation and is believed to be due to the protection offered by the overhead ground wire in diverting the stroke to ground. In regard to tower footing resistance they continue that "the better showing in Ohio was probably due to the lower average tower ground resistance in Ohio, mostly less than 10 ohms against one-third of more than 50 ohms in New Jersey."

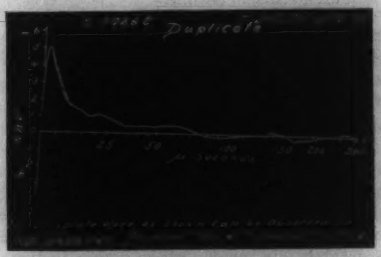


Fig. 21. 5,000-kv. surge measured 4 miles from point of stroke

All three phases flashed to ground splitting the wood-pole supporting structure and causing a circuit breaker operation. Also center conductor flashed 22 ft. to a telephone line at a crossing 3,600 ft. from the stroke

Data obtained in these field investigations have established without question the effectiveness of the conventional ground wire for protecting lines against lightning disturbances. In general it has been found that only in rare cases will a line conductor be struck when steel tower construction with conventional ground wires are used. The results show in addition that from two to three times as many interruptions occur due to lightning on lines without ground wires as occur on lines with ground wires installed.

It is reported by Lewis and Foust that out of 231 total interruptions on the transmission system of the Public Service Electric & Gas Company (New Jersey), only six have occurred on 66- and 132-kv. lines where overhead ground wires are installed. Mention is made also of a 14-mi. 66-kv. double-circuit steel-tower line operated by the Philadelphia Electric Company which is equipped with two ground wires, one placed vertically over each of the outermost conductors. This line has not experienced an outage due to lightning in fourteen years. The beneficial effect of low tower footing resistance also is well emphasized in this case since the resistances are all unusually low and uniform, being of the order of 4 ohms each. In this connection Fortescue and Conwell, speaking of the 220-kv. lines of the Public Service Electric & Gas Company, state that "during one year's investigation on lines equipped with ground wires, no flashovers have occurred where tower footing resistances are less than 5 ohms."

A direct comparison between lines with and without ground wires has been obtained by Bell and Price. This comparison is illustrated in Fig. 22, where the number of flashed insulators per tower per year has been plotted against tower footing resistance for each case. The effect of ground wires appears to be to reduce the number of flashovers to about 15 per cent of those which otherwise would occur. The effect of tower footing resistance at least above 17 ohms seems to be negligible in this case.

Some difference of opinon appears regarding the benefits of low tower footing resistance. It is quite generally agreed, however, that extremely low resistances (only a few ohms) do show a marked beneficial effect.

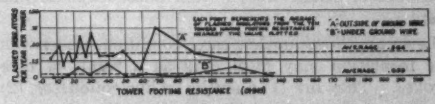


Fig. 22. Effects of tower footing resistance and overhead ground wires on insulator flashovers occurring on a 220-kv. line section

WAVE SHAPES

According to Lewis and Foust, oscillographic work on transmission lines under natural lightning conditions has shown that waves to be expected on transmission lines vary in time to crest from about 1 microsec. to several hundred, but that the tail of the wave extends over a much wider range. In general the lower voltage surges appear to be of longer time duration.

Wave shapes measured at or near the origin of surges have fronts which bring the conductor potential up to flashover values in the order of about 1 microsec. These high-amplitude waves of steep front usually cause flashovers and therefore are reduced quickly to low potential values. Apparently voltage waves rising to fairly high values, but still under insulator assembly flashover value, would possess a longer time to crest and also a wave tail of at least some 10 to 100 microsec. in length.

Wave fronts rising at the rate of from 1,000 to 2,500 kv. per microsec. have been measured in several cases, but Pittman and Torok in their test on a wood pole line found that surges at the point of origin may have a rate of rise of 4,000 kv. or more per microsec.

Sporn and Lloyd present curves showing approximate wave shapes for the maximum, minimum, and average wavelengths observed on 29 oscillograms recording 50 kv. on crest or higher, and therefore not causing flashovers (see Fig. 23). Wave shapes for higher voltage surges where flashover occurred are shown in other illustrations.

Bell and Price state that among other things the wave forms of lightning surges appear to be dependent upon whether the surge originated and created fault on the phase to which the oscillograph is connected, or on either or both of the other two phases.

Gross and Cox in speaking of attenuation agree that attenuation is greater for positive than for negative surges. They assert further that attenuation of high-voltage surges is very rapid, maximum crest values in

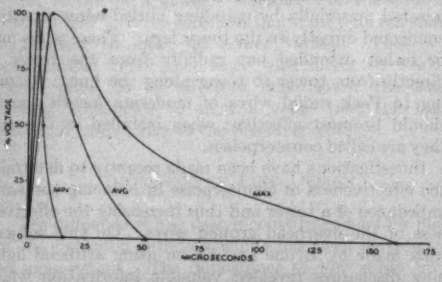


Fig. 23. Empirical wave shapes of lightning surges showing envelopes for maximum, minimum, and average time relations

the order of 2,000 kv. being reduced to one-half that value within about a mile. An empirical formula has been developed from actual measurements by which the voltage reduction or attenuation can be determined for any point on the line. This is illustrated in Fig. 24. This formula contains constants which depend upon the characteristics of the line under consideration, and agrees fairly well with results of attenuation studies where artificial lightning has been used.

Wave shape and attenuation studies of natural lightning discharges in general agree fairly well with the results of theoretical studies outlined previously, but in any case the wave shape of a particular surge appears to depend upon (1) whether the surge results from a direct stroke or is induced, (2) polarity, and (3) whether or not flashover takes place.

Polarity

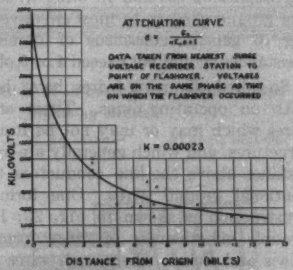
Some difference of opinion exists regarding the polarity of lightning discharges as evidenced by excerpts presented herewith. Bell and Price state that most lightning strokes are of negative polarity, as indicated by measured structure currents. Smaller proportions appear to be oscillatory with negative polarity predominating. Positive surge voltages between conductor and tower usually are indicated at locations where a ground wire or conductor not coupled to the surge voltage recorder is contacted by direct strokes. These therefore are not indications of induced surges due to cloud fields.

Gross and Cox report that 60 per cent of the conductor surges measured by them were negative, 40 per cent positive. Of the ground-wire surge voltages investigated, 70 per cent were positive, 21.5 per cent negative, 8.5 per cent oscillatory.

Sporn and Lloyd found that lightning surges were positive ten times as often as negative, but that each of the stroke recorder charts indicated the cloud to be negative. These authors advance the belief that overhead ground wires prevent the majority of negative lightning bolts from reaching phase wires and that, therefore, positive surges measured on the lines are due to induction.

Lewis and Foust state that measurements of cloud field potentials have established beyond question that fields of both polarities are present, and that field polarity at a point on the ground may change from positive to negative or from negative to positive during storm. Additional statements made by these authors, however, are to the effect that all lightning stroke recorder charts of direct strokes to tower indicate the tower to be negative. From this it is inferred that clouds are negative and the ground positive. With the tower structure positive with respect to the cloud, breakdown proceeds from structure to negative cloud, and the strokes terminate on the grounded structure under this polarity condition. Should the tower structure become negative with respect to clouds, strokes

Fig. 24. Attenuation curve and formula determined empirically from surge-voltage recorder data


ATTENUATION CURVE
DATA TAKEN FROM NEAREST SURGE VOLTAGE RECORDER STATION TO POINT OF FLASHOVER. VOLTAGES ARE ON THE SAME PHASE AS THAT ON WHICH THE FLASHOVER OCCURRED
K = 0.00023
KILOVOLTS
DISTANCE FROM ORIGIN (MILES)

would proceed from the cloud, and the probability of the tower being struck would not be great. While this conception appears to reverse the accepted picture of cloud-to-ground strokes, nevertheless it is said to be consistent by being in accord with laboratory and field experience.

Protection Against Lightning Surges

Requirements for a "lightning proof" line, where this seems justified economically, are outlined in this article. Insulation alone is not the final answer, only one of several important features of proper line design. A new arrester of the gap type is described also, wherein the breakdown medium is a column of air.

INSULATION FAILURES arising from lightning discharges are shown by experience to be the cause of a majority of transmission line outages. It is highly desirable, therefore, that protective measures be adopted and practical protective devices be installed to reduce the number and seriousness of such disturbances. That it is impractical to over-insulate a line sufficiently to withstand lightning voltages is substantiated by records which show that sometimes even on wood pole lines there are impressed surge potentials of sufficient magnitude to flash over the wooden structures to ground.

Overhead Ground Wires

The effectiveness of conventional overhead ground wires for lightning protection where steel tower construction is used has been well emphasized by the investigations covered in other articles of this group. For ground wires to be most effective, however, according to general consensus of opinion tower footing resistances should not exceed 4 or 5 ohms.

So-called diverting wires have been experimented with on operating lines. These are special ground wires which may or may not be insulated from tower structures, and which generally are located at a greater distance above the line conductors than are the conventional ground wires. One form of diverter-wire construction is shown in Fig. 25; Peek suggests the possible effectiveness of other forms. According to Lewis and Foust, where such wires are supported on the line towers the only advantage appears to be that due to the increased height of these wires whereas when insulated from the tower structure and provided with independent grounds of low resistance, they possess the distinct advantage of keeping lightning currents out of tower structures. Protection offered by conventional ground wires, however, is said to be such that only in cases of high tower footing resistances do diverting wires appear feasible.

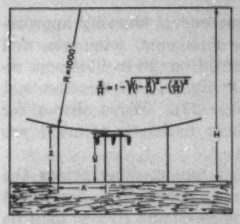


Fig. 25. One type of diverter for lightning protection where high tower footing resistance cannot be avoided. Z represents the minimum height

Tower Grounding and Counterpoises

Where tower footing resistance is too high for efficient ground-wire protection the resistance can be lowered materially by installing buried wires or cables connected directly to the tower legs. These wires may be either extended out radially from the tower or directly from tower to tower along the line. According to Peek radial wires of moderate length usually should be most effective; when installed in this way they are called counterpoises.

Investigations have been made recently to determine the effectiveness of counterpoise in reducing the surge impedance of a tower and thus increasing the effectiveness of the overhead ground wires. On this subject, tests made by Brune and Eaton using artificial lightning discharges revealed valuable information which will be outlined briefly in the following paragraphs.

Theoretically the counterpoise will tend to reduce tower footing voltages both by increasing the capacitance to ground (ground potential assumed to be at an appreciable depth below ground level) and by allowing leakage of charges from towers into the earth. On surge voltages, however, the time element enters in causing the counterpoise to behave like a line with a very high "leakance." Thus reflections may occur from the remote ends of the counterpoise cables and may make themselves felt at the tower footing ends.

For test purposes a tower location was selected where footing resistance measured at 50 cycles was rather high (400 ohms). Various arrangements of counterpoise were connected and surges discharged directly from the line into this grounding system. A probe was driven into the ground about 40 ft. away from the tower and the voltage was measured between that probe and the point at which the line was grounded. In some tests the line was grounded through a known resistance, the voltage across the resistance being taken as a measure of ground current.

Results of the first test are depicted in Fig. 26 where the curves show tower footing voltage for different lengths of counterpoise. As may be noted, extending the counterpoise in two directions produces practically double the effect of extending it in one direction only, but there is no great advantage apparent in extending

it further than 1,000 ft. Since this distance in most cases would be more than a full span length the counterpoise in reality would involve at least two spans. How much shorter than 1,000 ft. the counterpoise may be made and still be effective will depend upon the length of surge to be expected and particularly upon the length of the wave front. Counterpoise can be made much more effective by extending in more than two directions, but right-of-way limitations in most cases would constitute a practical obstacle to this.

Additional tests show that current and voltage relations in a counterpoise are not proportional. This fact emphasizes again the non-constant nature of surge impedance. It has been found also that for long wave-fronts the effectiveness of a counterpoise is greater than for short ones. For a surge of approximately rectangular front such as might arise from a direct stroke to a tower, "leakance" of the counterpoise would have no effect initially; only its resistance functioning to limit the tower voltage. This is of considerable importance since with direct strokes the counterpoise to be effective must lower the tower footing impedance to such a value that the tower potential cannot rise to the flashover point.

Influence of Line Design

The influence of line design constitutes another phase of the lightning situation which has been investigated to some extent. The importance of low surge impedance for the grounded supporting structure of a line has been duly emphasized and needs no further mention here. Certain other features, however, play an important part in determining how a certain line will react toward lightning disturbances.

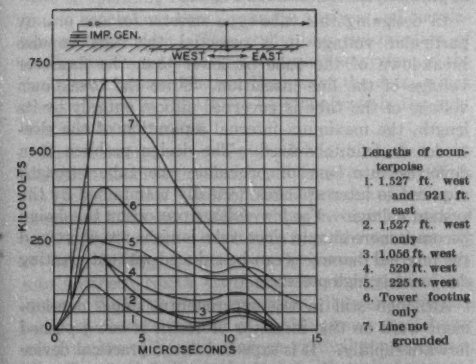
First and foremost it is important that, if possible, line structures be kept clear of high elevations since lightning has a natural tendency to strike the highest object within its range. Where lines must be run over high ground, trees adjacent to the right-of-way will provide some protection. It is desirable also that span lengths be kept as short as possible so that reflections (which have a tendency to reduce the tail of the wave) will return to the point struck in the shortest possible time and thus tend to shorten the wave.

As previously brought out, where high tower footing resistance cannot be avoided, special overhead ground-wire construction or diverters may be employed. Where the economics of the situation will permit, these may be placed in such a way that they will shield the line from direct lightning strokes.

Peek has devoted a great deal of attention to proper line design as regards lightning protection. From the results of his studies he concludes that a "lightning-proof" line for almost any voltage seems feasible. The general requirements for such a line are (1) low elevation, (2) short spans, (3) low tower footing resistance, (4) ground wires, special ground-wire constructions or lightning diverters where tower footing resistances are high, and (5) highly insulated conductors (using from 14 to 16 disk insulator units as is customary on the present 220-kv. lines).

Lightning Arresters and Gaps

The desirability of lightning arresters for protecting terminal equipment in substations is recognized generally. Lightning arresters also are finding some application on transmission lines, especially where provision for ground wires is not easily made. Arresters possess the distinct advantage of being easily placed at just the points where the protection is desired. Their most distinct disadvantage lies in the fact that



Lengths of counterpoise
1. 1,527 ft. west and 921 ft. east
2. 1,527 ft. west only
3. 1,056 ft. west
4. 529 ft. west
5. 225 ft. west
6. Tower footing only
7. Line not grounded

Fig. 26. Surge voltages at point of grounding for various lengths of counterpoise

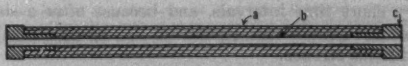


Fig. 27. Section of air-breakdown expulsion-type lightning arrester

(*a*) Fiber tube (*b*) Arc chamber (*c*) Metal electrode

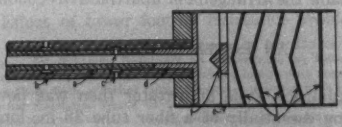


Fig. 28. Section of deionizing chamber for ends of expulsion arrester

(*a*) Inner fiber tube, (*b*) outer fiber tube, (*c*) gas vent, (*d*) electrode, (*e*) steel shell, (*f*) flame spreader, (*g*) perforated baffles

their protective effect does not extend more than 500 ft. from the points of application. This feature may prevent arresters coming into general use on transmission lines.

In general, lightning arresters may be grouped into two classes: (1) those which have valve action, acting as good conductors when the voltage rises to a definite predetermined value and as insulators when the voltage drops below some lower value; and (2) those which become good conductors when the voltage reaches a definite value and continue to pass current until the zero point of the current cycle is reached. Familiar examples of the first class are the so-called Thyrite and oxide-film arresters. Familiar examples of the second type are gap devices, both fused and non-fused, of which there are several designs.

Devices of the latter type, consisting of fused horn-gaps, were in use on the 110-kv. wood pole line on which Pittman and Torok conducted their tests. These devices were expected to discharge current incident to lightning surges, and to interrupt subsequent 60-cycle power currents sufficiently promptly to prevent oil circuit breaker operation. In thirteen distinct operations, each resulting in blown fuses, a total of six flashovers occurred, none of which caused a switch operation. In one case, however, a three-phase short circuit resulted from a 5,000-kv. surge which arose from a direct stroke to the line. Details of this event appear elsewhere in this symposium (see Fig. 21). All three fuses in the nearest horn-gap device (about one-half mile away) were found blown, but this did not prevent a switch operation. These results support the previous statement that the protective effect of such a drain point does not extend very far beyond the point of application, even where lines are as highly insulated as this one. Moreover a single fuse seemed inadequate because many flashes of lightning are made up of several successive discharges following each other at very short time intervals, and because after a single fuse has blown no protection is afforded against additional strokes.

A multiple-fuse device accordingly was installed at six locations providing three fuses so arranged that they would blow successively upon the occurrence of lightning surges of sufficient magnitude to cause the gap to flash over. Results were fairly satisfactory, but the necessary continuous patroling and replacement made the arrangement unattractive economically.

An Insulator Protector

An expulsion type of arrester then was developed consisting essentially of a fiber tube 38 in. long with a wire electrode in each end to reduce the effective arcing length to 30 in., insuring breakdown within the tube. This device was inserted without additional gaps into the line hardware grounding lead. Although these devices have been in use only a comparatively short time they have proved quite satisfactory; eight successful operations have been recorded.

Torok describes in detail some of the difficulties encountered in the development of this device. Some difficulty was encountered in devising assemblies in which breakdown within the tube could be assured. A most promising arrangement was found to be that in which the ratio of internal to external spacing was not greater than 0.85 (see Fig. 27). Some difficulty was experienced also in obtaining proper wall thickness of the tube, since repeated flashovers sometimes caused tube breakdown either by splitting or by puncturing.

In regard to its interrupting characteristics, Torok explains that with an arc established in a cylindrical hole a much higher voltage may be interrupted than if the arc is drawn in the open. If the hole is too small, however, only relatively small currents can be discharged through it. Slepian has shown that the effectiveness of a confining chamber can be increased many times by the use of a material which will produce a gas. With such material the heat of the arc volatilizes the surface of the walls at a rapid rate forcing into the arc stream an appreciable quantity of un-ionized gas. This gas greatly raises the arc voltage and the voltage which can be interrupted. In experimental installations the pressure developed within the tubes by the evolution of gas introduced mechanical difficulties which had to be overcome.

Deionizing Principles Applied

In addition to the mechanical difficulties involved, these tubes often flashed over on the outside because of the convection of ionized gases arising from sparkovers. Deionizing chambers attached to the ends of the tubes have been successful in controlling this condition. The deion principles already have been widely described; the mechanics of this particular application are indicated in Fig. 28.

In designing this tube-type arrester for use on any particular voltage it is essential that the impulse breakdown of the tube be lower than the flashover voltage of the line insulation. Since the breakdown voltage of the tube is governed almost entirely by its length, the maximum internal separation of the electrodes is definitely fixed. The design problem then devolves into one of providing the tube strength required to interrupt arcs normally maintained by the system voltage. For low-voltage protection the design becomes more simple since tube lengths are short and the internal diameters can be reduced without creating dangerously high pressures.

Although still in the experimental stage, development work on this insulator protector is being pushed forward rapidly. It is expected that a practical device which is simple in construction, easy to install, and capable of repeated operation without attention eventually will result.

Lightning versus System Operation

Operating experiences form the final proving ground of the many theories developed; the efficiency of any scheme of protection may be ascertained accordingly. Although one overhead ground wire already is known to be highly beneficial, two are shown to be unquestionably better. Opinions conflict as to the effect of tower footing resistance.

ACCORDING to Sporn's previously mentioned division of the lightning problem as it affects the operation of electric systems, the third part consists of practical operating records covering actual operating experiences where devices and designs for the mitigation of lightning damage are in use. This field experience properly analyzed and interpreted gives the final answer as to the tenability of the many theories developed in connection with lightning and as to the practicability of methods or structures devised to eliminate harmful lightning effects.

Of necessity some of the previous sections of this symposiac have included material which can be classed as operating results. It would be difficult for instance to separate out such results obtained in field investigations of natural lightning where these have been carried on with the lines in operation. Sporn, however, has presented the results of a study made entirely upon the basis of operating records and data and has arrived at certain conclusions based upon the analysis and correlation of those data. This study is a continuation of similar studies made on the transmission system of the American Gas and Electric Company; the data, which were collected in 1929, have been analyzed in the light of previous experiences.

The transmission systems studied have been described in detail in previously published articles. With the exception of a few recent additions the system now comprises 1,198 mi. of 132-kv. lines involving a total of 1,825 circuit miles. It extends from the southern tip of Lake Michigan, southeasterly across the country into northern North Carolina, covering parts of ten states. With one minor exception all lines within the range of observation are of double-circuit steel tower construction with conductors in vertical configuration; all utilize A. C. S. R. conductors, (with a single ground wire of the same material) supported by ten disk units in suspension and twelve on dead ends. Practically all lines are equipped with some sort of arcing protection for insulator strings.

During 1929, 652 observed storms were reported by stations scattered throughout the system. Of these some 565 occurred during the period from April to August inclusive. Recorded lightning outages for the entire system amounted to 133 in 1928 and 248 in 1929. The increase, while due partly to an increase in miles of transmission lines, is attributed largely to the more severe lightning storms which occurred in the region during 1929. A thorough analysis of the operating records and experiences made and interpreted in the light of previous lightning experience on the same system can be summarized as follows:

Summary of Sporn's Results

1. Two-circuit lines are better than single-circuit lines.

When installed in vertical configuration on the same towers, the use of two-circuit lines enhances system reliability to proportions greater than does the mere doubling of the circuits. Experience indicates definitely that only from 16 to 29.5 per cent of the trip-outs involve both circuits, and it is likely that this percentage can be reduced by higher speed switching.

2. One ground wire is good; two are better.

The only line equipped with two ground wires had 3.6 outages per 100 mi. of line per year; the only line not equipped with a ground wire had an outage record of 75. A line operating in 1929 with one ground wire had 37.4 outages per 100 mi. of line per year; operating in 1928 with no ground wire this line had the 1929 equivalent of 59.3 outages per 100 mi. of line. This clearly shows the benefits of one ground wire, and definitely indicates that two ground wires are more beneficial than one.

3. Grading shields protect insulators only.

Grading shields have little effect on the lightning outages of these 132-kv. lines; but they definitely limit the damage to insulators and conductors, and reduce the amount of cascading required. Over the entire system (most of the system being equipped with grading shields) 23 per cent of the total number of tower flashovers occurred on cascaded strings. The lines on which grading shields were installed recorded only 21 per cent; lines with no shields, 70 per cent. This is a striking indication of the benefit rendered by grading shields.

4. Misleading conclusions may be drawn.

No interpretation of performance of lines under lightning conditions is possible or of real value without an accompanying record of lightning-storm conditions during the particular time discussed. Otherwise, conclusions gravely misleading may be reached.

5. Only one conductor usually involved.

Records of physical inspection and relay-target indications show that in from 4.7 to 5.8 per cent of trip-out cases due to lightning, all three phases are involved; in from 44.2 to 45.2 per cent, the top and middle conductors only are involved; in from 42.8 to 44.3 per cent the bottom and middle conductors are involved; and in from 73.2 to 64.2 per cent one phase only is involved. This analysis strongly indicates that both direct and induced strokes are of vital importance in the performance of this 132-kv. network.

6. Effect of tower footing resistance problematic.

Detailed data on the tower footing resistances on four 132-kv. lines show no tendency for lightning flashovers to concentrate on towers of high footing resistance in preference to those having low footing resistance. In fact, from these data, whether lightning strikes a tower with low or with high footing resistance seems to be a matter of chance. Flashed-over towers were observed to have footing resistances ranging from 1.5 to more than 250 ohms; and 65 per cent of all recorded flashovers occurred at towers having footing resistances of 20 ohms or less while less than 8 per cent occurred where this resistance was 80 ohms or more.

In general there is close agreement between these conclusions and those arrived at on the basis of the

special field investigations. By way of comparison, however, it seems pertinent to mention the following points:

It is generally agreed that efficient ground-wire protection will reduce greatly the number of line outages due to lightning. Bell and Price have found in addition that a counterpoise greatly improves the efficiency of ground-wire protection and thus provides an additional factor of safety, especially where tower footing resistances are high. Fortescue and Conwell state that ground-wire protection near stations should be especially good in order that station equipment (which usually is not as highly insulated as the lines) be provided with the greatest possible amount of protection.

In regard to induced surges versus those caused by direct hits, Bell and Price believe that only in rare cases are induced voltages of sufficient magnitude to cause flashovers on 220-kv. lines. Pittman and Torok in speaking of wood pole lines also state that voltages dangerous to line insulation and equipment in most cases are set up only by direct hits.

There seems to be some disparity in regard to the effectiveness of low tower footing resistance. Fortescue and Conwell report no flashovers on lines equipped with ground wires where footing resistances were less than 5 ohms. Lewis and Foust support this view by calling attention to a 14-mi. 66-kv. double-circuit steel tower line of the Philadelphia Electric Company which has not suffered a lightning interruption for 14 years. This particular line has tower footing resistances of about 4 ohms each and is equipped with two overhead ground wires. Gross and Cox state definitely that an attempt to relate line flashovers to tower footing resistances proved futile while Bell and Price say that the effect of footing resistances higher than 17 ohms seems to be negligible.

Single Patent Appeal Court is Proposed

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On the basis of long practical experience the author condemns the present procedure in patent litigation and outlines the foundation for a proposed single United States Court of Patent Appeals which would be second only to the U. S. Supreme Court and would abolish the duplicate and conflicting efforts of the ten district courts in patent matters. Full text of a proposed House of Representatives bill is given.

BECAUSE of the peculiar nature of the patent monopoly, the present system of appeals in patent infringement suits in the United States is the most inefficient, expensive and wasteful to be found anywhere. It is a deterent to the production of inventions, and to the investment of capital in patents. Correction of this condition is by far the greatest need of our patent system.

Present System—Nature and Defects

For the first century of our patent system, there was a single court of patent appeals, the Supreme Court of the United States. This court became so overburdened with work that, in 1891, the appeal to the supreme court was taken away; and the country was divided into nine circuits (now ten), each of which was provided with a circuit court of appeals, having final and supreme jurisdiction of all patent appeals in its circuit.

These courts are independent of each other. While, under the doctrine of comity and unless they see substantial reasons for not doing so, they follow a previous decision by the court of appeals of another circuit on the same patent, they are at liberty to decide oppositely and frequently do so.

As stated, there is no appeal to the supreme court except that of petitioning that court to grant a writ of certiorari ordering the case to be sent up to it. The supreme court has such an enormous volume of work that it does not take up a patent case unless there is some question of public importance, of interpretation of law, or unless two circuit courts have decided the same question concerning the same patent in opposite ways. The decision of a single circuit court of appeals is final in most branches of the law (practi-

Essentially complete text from a pamphlet released May 25, 1931, by Edwin J. Prindle, chairman of the American Engineering Council's patent committee, 111 Broadway, New York, N. Y.

cally the only other exceptions being copyright and trade-mark matters). This is not so as to patents.

The monopoly which a patent grants is a negative one. The patentee is not granted the right, himself, to make, use or sell the patented invention—a *positive* monopoly. He already has that right because of his inventorship, unless in doing so he would have to use that which has already been patented to another. The patent merely grants him the *negative* right to exclude all others throughout the United States, from making, using and selling the patented invention. To be of any value to him, his monopoly must be maintained inviolate. If there is one infringer anywhere in the United States who has been rendered immune from the patent by a final decision, it will greatly impair and may largely destroy the value of the patent. One hole that cannot be stopped may sink a ship.

Under these circumstances, to make it necessary that the patent shall have been adjudicated oppositely in two separate circuit courts of appeal before the mere right shall exist to petition the one court which can render a final decision, the supreme court, to take it up is a shocking economic waste. A patent may be valid in one circuit and invalid in another. It may have been given a broad, inclusive, interpretation in one circuit, and a narrow one in another. It may be infringed by a given construction in one circuit, and not infringed by the same construction in another. A defendant in whose favor a patent in one circuit has been held invalid, or not infringed, is free to make, use, and sell in every other circuit; the patentee cannot even enjoin his agents or customers. Thus, in a single circuit, a patent may be invalid as to one person or corporation and valid as to everyone else, or *vice versa*. Even if a patent has been sustained in two circuits, there still are eight circuits, any one of which could decide to the contrary.

If the first of two decisions by a different circuit court of appeals is against a patent, and the supreme court decides in favor of the patent, it almost invariably is too late for the decision of the supreme court to affect the first case; and the defendant in that case is free to infringe the patent throughout the remainder of its life and throughout the whole country. Furthermore, the statute provides that where the patent covers more than the patentee invented he must, with reasonable promptness, file a disclaimer in the U. S. Patent Office disclaiming that which is not his invention. Where in the first suit under the patent a court of appeals holds a claim to be invalid, it must promptly be disclaimed under penalty of the patentee losing the right to bring other suits under the patent. The law provides that the disclaimer becomes a part of the patent, and is effective throughout the United States in all circuits. Thus patents may be nullified irretrievably because of a plurality of courts of appeals. With a single Court of Patent Appeals, the validity of the claims could be finally determined before any disclaimer was filed. Moreover, by the time the patentee has obtained a favorable decision in a second circuit in any of these cases, much of the short life of the patent (seventeen years) usually has expired with no substantial reward to the inventor. Expenses of these repeated litigations make them impossible to the individual, and constitute a burden from which even large corporations shrink.

With ten courts of appeals there are unavoidable differences of opinion on various points of law and differences of tradition as to the liberality or strictness of construction to be applied to a patent under the same circumstances. Under a single court of patent appeals the administration of the patent law would attain completeness and certainty and uniformity of application now lacking in these and other respects. Patents also involve many difficult questions of science and engineering, upon which judges may and often do differ. Thus it is impossible for the decisions of various circuit courts of appeals on the same patent always to be uniform.

Quite as many adjudicated patents are held to be invalid as are sustained. Both the public and the patentee, therefore, need to know early in the life of the patent whether or not the patent is valid, and what is its scope. If the patent is invalid the public should know it through a single final decision, and not be kept in uncertainty for years during which it would have been free to use the alleged invention described in the patent. However, if a patent is valid, the patentee early in the life of his patent should have a single decision which applies throughout the United States and which would hold against all subsequent defendants, unless they set up defenses substantially different from those considered in the first suit, or unless they use a structure outside the monopoly of the patent as determined in the first suit.

The patent should be adjudged as to validity, scope and infringement, on the same principles and policy throughout the United States, both for the sake of the public and the patentee. The head of the patent department of one of the largest corporations in this country said to the writer recently, "Whether a patent is valid or invalid, we want, early in its life, to know definitely so that we may shape our course accordingly and with confidence that the situation will not be changed during the life of the patent, except for substantial reasons."

The only solution of the difficulty is a "single court of patent appeals."

History of Legislative Efforts

In 1903 the American Bar Association approved the principle of a report of its patent committee recommending the establishment of a single court of patent

appeals, and directed that committee to lay a bill for that purpose before Congress. The particular bill then proposed was not approved, but the principle of a single court of patent appeals was approved, leaving the form of the bill open. Mr. Frederick P. Fish was chairman of the patent section, and vigorously advocated the bill, which provided for a chief justice, appointed for life, and six judges chosen from the circuit and district courts to sit for terms of six years each.

Both the 1903 attempt and a subsequent attempt made in 1919 failed, however. The House Committee refused to approve the bill because it became apparent that judges would not break up their homes and interrupt their friendships and their children's schooling and go to Washington merely for a term of six or possibly twelve years. It became clear that appointments would have to be permanent to induce judges to become members of the proposed court.

Meanwhile, the need for a single court of patent appeals has been growing constantly. Such a court is now a practical necessity. It would substantially stimulate inventing and would protect both the patentee and the public from enormous unnecessary expense.

The American Engineering Council recently has approved renewing the legislative effort with a bill curing the former objections. The National Association of Manufacturers again has passed a resolution approving of the principle of a single court of patent appeals, and the undertaking of another campaign at this time to enact a bill for the purpose. Also, various committees of patent law associations are considering the advisability of a renewed effort to secure a single court of patent appeals.

Provisions of Proposed Bill

The writer has prepared a bill which provides for a single court of patent appeals sitting at Washington, and composed of a chief justice and six associate judges, five of the seven judges to constitute a quorum. Not only the chief justice, but the associate judges are to be appointed, as the Constitution says, "during good behavior." The proposed court is to have final jurisdiction of all appeals in patent cases from the District Courts of the United States and from the Supreme Court of the District of Columbia, both in interlocutory and final orders and decrees, jurisdiction of the United States Circuit Courts of Appeals in patent appeals being abolished. The power of the Supreme Court of the United States to order cases certified to it, is extended to include the proposed single court of patent appeals, and the right is given to that court to certify questions to the Supreme Court for instructions.

Salaries of the chief justice and the associate judges of the single court of patent appeals as proposed are $13,500 for the chief justice, and $13,000 for the associate judges. These are higher than those of the circuit courts of appeals, thereby ranking the single court of patent appeals next to the Supreme Court of the United States. This undoubtedly would assure that a sufficient number of the best qualified judges in patent cases will be available for appointment to the proposed court.

That the judges shall be specially qualified for the adjudication of patent cases in the single court of patent appeals, the bill provides that "experience in the adjudication of a substantial number of patent cases on the federal bench, or in the practise of patent law in the federal courts, shall be requisite to appointment as chief justice or a judge of said court, to the end that only judges who have shown special aptitude for the adjudication or the practise of the patent law shall be appointed to said court." Further experience and observation show that, by the adjudication of many patent cases, they would acquire a facility for comprehending the science and engineering of patent cases which would enable them, to a much greater extent, to make a selection on their own judgment between the conflicting opinions of experts.

The proposed bill changes the name of the court of customs and patent appeals to the "court of customs and patent office appeals," and it does not provide for appeals therefrom to the single court of patent appeals. However, an applicant for a patent (in every case except where the commissioner of patents is a necessary party, instead of appealing from the commissioner of patents to the court of customs and patent appeals) could reach the proposed single court of patent appeals by appeal on a bill in equity filed in the Supreme Court of the District of Columbia or, where the opposing party in the interference is not a resident of the District of Columbia, by an appeal on a bill filed in the district court of the district of which his opponent is a resident.

The establishment of a United States Court of Patent Appeals not only would be a great benefit to patentees and to the public, but will increase the effectiveness of patents, and prolong the productive portion of their terms. It would also substantially stimulate inventiveness and the building of businesses under patents. Establishment of the U. S. Court of Customs Appeals (now the U. S. Court of Customs and Patent [Office] Appeals) affords a precedent for the establishment of a single U. S. Court of Patent Appeals.

It is believed to be entirely possible to secure the establishment of a single court of patent appeals at this time if sufficient support is given by those who realize the importance of the patent system to the United States.

Attention is invited to the following draft of the proposed bill for a single court of patent appeals, the principal provisions of which have just been outlined.

COMPLETE TEXT OF PROPOSED H. R. BILL

IN THE HOUSE OF REPRESENTATIVES

A BILL

To Establish a Single United States Court of Patent Appeals, To Change the Name of the United States Court of Customs and Patent Appeals, and for Other Purposes

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, that there is hereby created an United States Court of Patent Appeals, which shall consist of seven justices, of whom five shall constitute a quorum, and shall be a court of record with jurisdiction as is hereinafter limited and established. Such court shall prescribe the form and style of its seal and the forms of its writs and other process and procedure as may be conformable to the exercise of its jurisdiction as shall be conferred by law. It shall have the appointment of the marshal of the court, who shall have the same powers and perform the same duties under the regulations of the court as are now provided for the marshal of the Supreme Court of the United States, so far as the same may be applicable. The Court shall also appoint a clerk, who shall have the same powers and perform the same duties now possessed and performed by the clerk of the Supreme Court of the United States, so far as the same may be applicable. The salary of the marshal of the court shall be $3,500. a year, and the salary of the clerk shall be $5,000. a year, both to be paid monthly in twelve equal payments. The costs and fees now provided by law in the Supreme Court of the United States shall be the costs and fees in the United States Court of Patent Appeals; and the same shall be collected, expended, accounted for, and paid over to the Treasury Department of the United States in the same manner as is provided by law in respect to the costs and fees in the Supreme Court of the United States. The Court shall have power to establish all needful rules and regulations for the conduct of its business within its jurisdiction as conferred by law.

Sec. 2. That the President of the United States, by and with the advice and consent of the Senate, shall appoint a chief justice, and six associate justices of said United States Court of Patent Appeals, and as vacancies occur shall in like manner appoint others to fill such vacancies from time to time. The acceptance of one of said offices by a circuit or district judge of the United States shall vacate his office as circuit or district judge. Experience in the adjudication of a substantial number of patent cases on the Federal bench or in the practice of the patent law in the Federal courts shall be requisite to appointment as chief justice or an associate justice of said court, to the end that only judges who have shown special aptitude for the adjudication or the practice of the patent law shall be appointed to said court. Appointment to said court shall be during good behavior.

Sec. 3. That a term of the United States Court of Patent Appeals shall be held annually at the City of Washington, beginning on the second Tuesday of October in each year, and the same may be adjourned from time to time as the court shall order. If at any time for the meeting of the court a quorum of the justices shall not be present, the justices present may adjourn the court and, if necessary, adjourn again from time to time until a quorum appear. If at any sitting of the Court, the Chief Justice shall be absent, the associate justice senior in commission as a circuit judge, or senior in age in case of commissions of even date, shall preside. If no associate justice who has been a circuit judge shall be present, the associate justice senior in commission as a district judge shall preside. In case of commissions of even date, the justice who is senior in age shall preside. Upon a request of the Chief Justice, or a presiding associate justice of The Court of Patent Appeals, the Chief Justice of the United States shall designate a judge, or judges, of any federal court to fill a temporary vacancy in the said Court of Patent Appeals. Until it shall otherwise be provided by Congress, the sessions of the court shall be held in a building or rooms to be provided by the marshal of the District of Columbia, under the direction and approval of the Attorney General of the United States. The court shall by order authorize its marshal to employ such deputies and assistants for himself and the clerk of the court and such criers, bailiffs, and messengers as the business of the Court shall require, and to pay the salaries of such employees at rates of compensation not exceeding those paid for similar services in the Supreme Court of the United States, and to pay all other necessary incidental expenses of the court. The Chief Justice and each of the Associate Justices shall be entitled to employ a clerk, whose salary, at a rate not exceeding that allowed the clerks of the Chief Justice and associate justices of the Supreme Court, shall be paid as part of the expenses of the Court. The Court shall have power, in its discretion, to appoint a reporter and to fix by order his salary or other compensation and direct the form and manner of the official publication of its decisions.

Sec. 4. That the Chief Justice of the United States Court of Patent Appeals shall receive a salary of $13,500. per year. The Associate Justices of the said court shall each receive a salary of $13,000. per annum. All the said salaries shall be payable in twelve equal monthly installments. The time during which any Justice shall serve in said court shall be deemed continuous service with that in any other court of the United States, before or after such service within the meaning and intent of Section Three Hundred and Seventy-five of title Twenty-eight of the United States Code.

Sec. 5. That the United States Court of Patent Appeals shall have jurisdiction to hear and determine appeals from final judgments and decrees in the district courts of the United States and in the Supreme Court of the District of Columbia in cases arising under the laws of the United States relating to patents for inventions, and from final judgments and decrees in cases arising under the laws of the United States relating to patents for inventions rendered by any other court having jurisdiction under the laws of the United States to hear and decide such cases in the first instance: Provided, however, that it shall have no jurisdiction of cases originating in the Court of Claims nor of cases in which the Commissioner of Patents is a necessary party. All such appeals shall be taken within three months after the entry of the order, judgment, or decree sought to be reviewed. The practice, procedure, and forms to be observed in the taking, hearing and determination of such appeals shall conform to the practice, procedure, and forms observed in like cases in the Supreme Court of the United States, subject to such rules and regulations as shall be prescribed by the Court. The said Court shall have power to prescribe the forms of records on appeals thereto.

Sec. 6. That whenever, by an interlocutory order or decree in a district court of the United States, in the Supreme Court of the District of Columbia or other Court having jurisdiction under the laws of the United States to hear and decide in the first instance cases arising under the patent laws, in a case in which an appeal may be taken from the final decree of such court to the United States Court of Patent Appeals, an injunction or restraining order shall be granted, or refused, or continued, or vacated, or modified, or retained without modification after motion to modify the same, an appeal may be taken from such order or decree by the party aggrieved to the United States Court of Patent Appeals: Provided, That the appeal must be taken within thirty days from the service of notice of entry of such order or decree: and it shall take precedence in the appellate Court; and the proceedings in other respects in the court below shall not be stayed unless otherwise ordered by that court, or the United States Court of Patent Appeals, or a judge thereof, during the pendency of such appeal.

Sec. 7. That the chief justice and the associate justices of the United States Court of Patent Appeals shall each exercise the same powers in term and vacation in the allowance of appeals, supersedeas orders, and other matters incidental to the jurisdiction and business of the Court as are now exercised by the Chief Justice and associate justices of the Supreme Court of the United States in relation to the business and jurisdiction of that Court.

Sec. 8. That the decisions of the United States Court of Patent Appeals in all cases within its appellate jurisdiction shall be final, except that it shall be competent, as hereinafter provided for the Supreme Court of the United States to require, by certiorari, or otherwise, any such case to be certified to it for its review and determination with the same power and authority in the case as though it had been carried by appeal from the trial court directly to the Supreme Court.

Sec. 9. That whenever any case shall have been certified from the United States Court of Patent Appeals to the Supreme Court of the United States, by certiorari or otherwise, it shall, upon its determination by the Supreme Court, be remanded to the district court of the United States or other court in which it originated for further proceedings to be taken in pursuance of such determination. And in every case determined by the United States Court of Patent Appeals upon appeal, the case shall be remanded to the District Court of the United States or other Court from whence it came, for further proceedings to be taken in pursuance of such determination.

Sec. 10. That all appeals in cases in which appellate jurisdiction is by this Act conferred upon the United States Court of Patent Appeals which shall have been pending without hearing in the United States Circuit Courts of Appeals or other court of appellate jurisdiction for less than three calendar months prior to the taking effect of this Act shall be transferred from such circuit courts of appeals or other courts to the United States Court of Patent Appeals and be heard and determined in that court as though they had been taken there from the trial courts by appeal without further payment for certifying the record or any new or additional docket or calendar fee; all other appeals and writs of error in cases in which appellate jurisdiction is by this Act conferred upon the United States Court of Patent Appeals which shall be pending in the United States circuit courts of appeals or other courts of appellate jurisdiction at the time of the taking effect of this Act shall remain and be heard and determined by the courts in which they may be pending, respectively, as though this Act had not been passed.

Sec. 11. That after the taking effect of this Act no appeal shall be taken from any district court or from the Supreme Court of the District of Columbia or other Court of the United States to any United States circuit court of appeals or other appellate court in any case in which an appeal may be taken to The United States Court of Patent Appeals under the provisions of this Act. If, in any case, it is found that no substantial question under the patent laws is raised by the appeal, the court may order that such appeal be sent to the circuit court of appeals having jurisdiction over the district in which the suit was brought, or the Court of Appeals of the District

of Columbia, as the case may be; if any appeal shall be taken to any circuit court of appeals, or to the Court of Appeals of the District of Columbia, and such court shall find that such appeal involves a question arising under the patent laws of the United States, except in a case where the Commissioner of Patents is a necessary party, such court shall order such appeal to be sent to the Court of Patent Appeals, and no appeal shall be dismissed solely on the ground that the appeal has been taken to the wrong court.

Sec. 12. Section 301a of Title 28 of the United States Code is hereby amended to read as follows:

> The title of the United States Court of Customs and Patent Appeals, created by Section 301 of this title, is hereby changed to The United States Court of Customs and Patent Office Appeals.

Sec. 13. Section 346 of Title 28 of the United States Code is hereby amended to read as follows:

> In any case, civil, or criminal, in The United States Court of Patent Appeals, in a Circuit Court of Appeals, or in the Court of Appeals of the District of Columbia, the Court may at any time certify to the Supreme Court of the United States any questions or propositions of law concerning which instructions are desired for the proper decision of the cause; and thereupon the Supreme Court may either give binding instructions on the questions and propositions certified or may require that the entire record in the cause be sent up for its consideration and thereupon shall decide the whole matter in controversy in the same manner as if it had been brought there by writ of error or appeal

Sec. 14. Paragraph (a) of Section 347, Title 28 of the United States Code is hereby amended to read as follows:

> (a) In any case, civil or criminal, in a circuit court of appeals, or in the United States Court of Patent Appeals, or in the Court of Appeals of the District of Columbia, it shall be competent for the Supreme Court of the United States, upon the petition of any party thereto, whether Government or other litigant, to require by certiorari, either before or after a judgment or decree by such lower court, that the cause be certified to the Supreme Court for determination by it with the same power and authority, and with like effect, as if the cause had been brought there by unrestricted writ of error or appeal.

Sec. 15. That Sec. 377, Title 28 of the United States Code, be amended to read as follows:

> "Power to issue writs. The Supreme Court, and the District Courts shall have power to issue writs of *scire facias*. The Supreme Court, the Court of Patent Appeals, the Circuit Courts of Appeals, and the District Courts shall have power to issue all writs not specifically provided for by statute, which may be necessary for the exercise of their respective jurisdictions and agreeable to the usages and principles of law."

Sec. 16. That all laws and parts of laws inconsistent with the provisions of this Act are hereby repealed.

Sec. 17. That this Act shall take effect and be in force on the day of nineteen hundred and

Twin Motors for Heavy Rolling Mills

By
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Twin-motor drive has met effectually the repeated demands for more power at the rolls. Other advantages, however, which now far overshadow the improvement originally sought are the direct outcome of the reduced inertia and greater operating flexibility inherent in this type of drive.

TWIN-MOTOR DRIVE for heavy blooming and slabbing mills has grown out of an increasing demand for power at the rolls greater than can be provided conveniently by conventional design methods. At the same time, this new development is a logical step in the modern trend toward greater mechanical simplicity in rolling-mill machinery. Already two machines, one a 54-in. blooming mill, the other a 44-in. slabbing mill, each with main rolls driven by independent motors, are in successful operation.

From "Twin-Motor Drive," presented at the convention of the Association of Iron and Steel Electrical Engineers, Cleveland, Ohio, June 15-19, 1931. A. I. & S. E. E. headquarters, 1010 Empire Bldg., Pittsburgh, Pa.; J. F. Kelly, managing director.

The principal advantages which these installations have exhibited can be summarized as follows:

1. Greatly increased motor capacity may be applied to a single pair of rolls.
2. Pinion losses with their attendant repair and maintenance are eliminated.
3. Twin motors may be designed to have greatly reduced inertia. This means less strain on equipment, more torque available for useful work, reduced motor and generator heating, and greater acceleration.
4. Roll chatter and spindle vibration are practically eliminated.
5. Higher rolling speeds can be maintained and mill tonnage can be increased.

The term "twin-motor" has come to refer to a form of rolling-mill drive in which each of a pair of rolls is independently driven by a separate motor. In a true twin-motor drive the motors may not operate at exactly the same speed at all times; nor do they depend entirely upon the coupling effect of the metal being rolled to maintain correct load division and speed relations.

Independent drive for the working rolls has been used previously in wheel and tire mills, piercing mills, and tube expanders and reelers. In these installations the motors rotated in one direction only at practically constant speed, the metal between the rolls providing an

effective coupling and rather definitely fixing the speed and load relations. Reversing-beam mills with independently driven edging rolls also were in successful operation. Here experience demonstrated that the speed relations of two reversing motors working on the same piece of steel could be adjusted to take care of varying drafts with no indication of unusual roll slippage.

When the electrical equipment for the 54-in. blooming

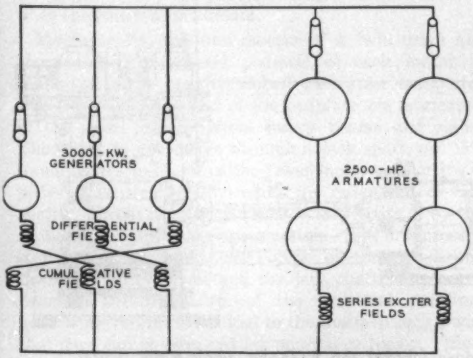

Fig. 1. Main connection diagram for 10,000-hp. twin-motor drive and associated generators

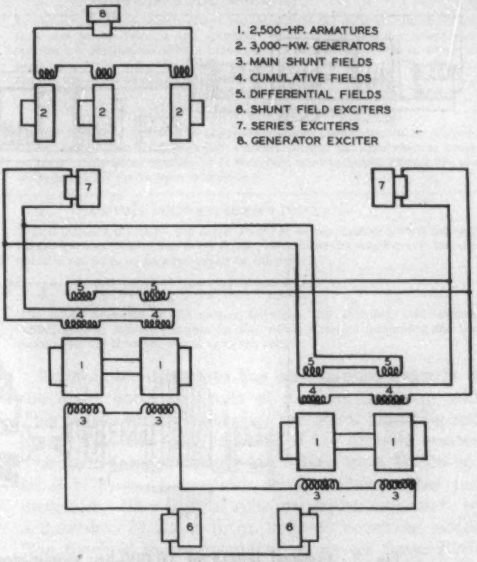

Fig. 2. Field-circuit connections for 10,000-hp. twin-motor drive

mill first was considered it was felt that, to provide power for rolling heavier sections at higher tonnage rates, the continuous capacity and maximum torque of the reversing motor should be greater than had been used previously.

Accordingly both 10,000- and 12,000-hp. equipments with maximum torques of 3,940,000 and 4,725,000 lb-ft. respectively were considered, since a duplicate mill already had been built with an 8,000-hp., 50-r. p. m. drive having a rated maximum torque of 2,500,000 lb-ft. It was thought then that for the higher motor torques the drive for the new mill could be improved mechanically by eliminating the mill pinions. This mechanical improvement now has been realized but other advantages as outlined in the beginning so far outweigh those expected that what previously were considered foremost, now seem insignificant. This, of course, is the usual story of many new developments.

Design Difficulties Involved

Design of reversing equipments for machines of this size presents some interesting problems. A motor with a single-unit armature would have the advantages of simplicity and comparatively high efficiency. However, the maximum capacity which so far has been built into a single-unit armature is 8,000 hp. at 40 r. p. m., and a motor of this size has an armature which approaches the largest that can be shipped in one piece. Using present design proportions, about 10,000 hp. continuous capacity at 40 r. p. m. with 3,300,000 lb-ft. maximum torque would be the largest motor which could be built with a single-unit armature. The inertia of such a motor, however, would be tremendously high—in fact about 2.3 times that of the 10,000 hp. twin-motor drive finally adopted.

A double-armature motor offers the next best possibility for a single machine of 10,000- or 12,000-hp. capacity at a speed of the order of 40 r. p. m., but even in this type of machine, the inertia would be nearly twice that of an equivalent twin-motor drive. Construction of the electrical equipment for high-capacity reversing drives thus obviously is somewhat more complex than for small and medium ratings.

In addition to the disadvantages of large single-motor drives already mentioned, pinion stands suitable for transmitting torques of from 4,000,000 to 5,000,000 lb-ft. become extremely large and heavy and their design and manufacture involve serious mechanical problems. For large mills, therefore, the twin-motor drive offers both mechanical and electrical advantages.

The twin-motor drive finally selected for the 54-in. blooming mill consists of two 5,000-hp., 40/80-r. p. m. double-armature motors with a combined maximum torque rating of 3,940,000 lb-ft. Each armature is wound for 350 volts, the two armatures of one motor being connected in series, as shown in Fig. 1. The two motors operate in parallel and receive power from three

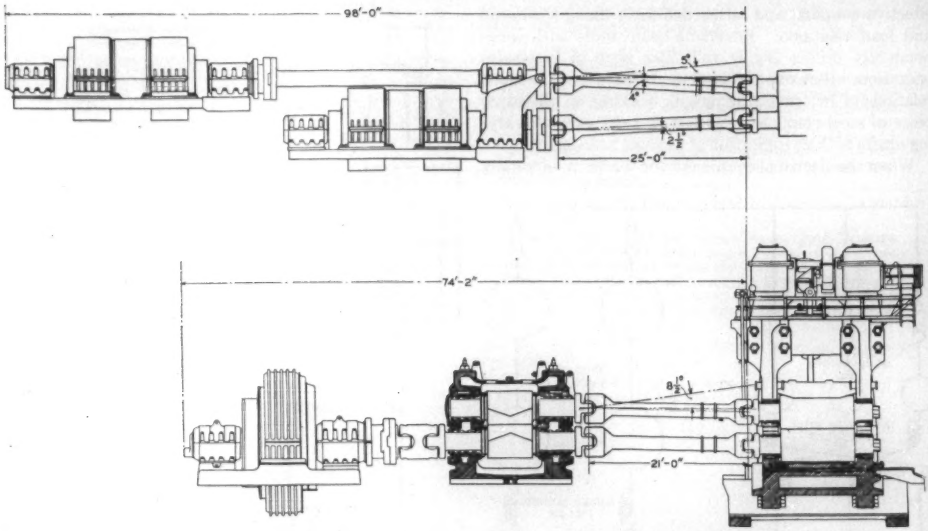

Fig. 3 General layout of 10,000-hp. twin-motor drive (above) and 8,000-hp. single-motor pinion drive (below) for 54-in. blooming mill. Note comparative space requirements

3,000-kw., 700-volt generators, also connected in parallel. The motor-generator is equipped with a 90-ton, 15-ft. diameter steel-plate flywheel, and is driven by a 6,500-hp., 368-r. p. m. induction motor.

Electrical Features

A diagram of the field circuit showing the method of field control may be seen in Fig. 2. All shunt fields of both double-armature motors are connected in series, thus insuring the same shunt-field excitation for both motors. As may be noted, two shunt-field exciters are employed for the motors in order to permit the use of standard 250-volt exciter generators. This arrangement also makes possible the variation of the relative shunt excitation of the two mill motors, if necessary, by means of a buck-and-boost exciter connected across the midpoint of the field circuit and a point midway between the two exciters. Up to the present time, however, no occasion has been found to make use of this latter feature.

In addition to the main shunt-field winding each motor is equipped with a cumulative series field and a differential series field which are cross-connected and indirectly excited by series exciter generators. As shown in Fig. 2 each series exciter generator has its series field in the armature circuit of one double-armature motor, and excites the cumulative field of that motor and the differential field of the other motor. Hence any tendency of one motor to take more than its share of the load strengthens its field and weakens the field of the other motor, thus quickly reestablishing equilibrium.

With this load-balancing scheme, any desired speed regulation can be obtained without interfering with the load-balancing characteristics—a valuable feature indeed. Of note also is that the load-balancing effect can be varied without affecting the compounding.

A similar scheme is used to balance the loads on the three generators of the motor-generator set except that the generator series fields are excited directly without the use of series exciters, and that each generator excites its own differential field and the cumulative field of the adjacent generator.

Mechanical Features

Mechanical arrangement of motor, spindles, and rolls is shown in Fig. 3. The motors are mounted on on 83.5-in. centers. Relative elevations of motors and rolls are such that the lower spindle operates at an angle of 2.5 deg.; the upper spindle runs at an angle of 4 deg. below horizontal when the rolls are together and 5 deg. above horizontal when the rolls are set for their maximum separation. The mill spindles are 25 ft. long, which is 4 ft. greater than for a duplicate mill with pinions. The maximum angle of the upper spindle for the pinion drive, corresponding to the same roll separation, is 8.5 deg.

Comparative space requirements and spindle angles

for an 8,000-hp., 40-r. p. m. drive with pinions, and for a 10,000-hp., 40-r. p. m. twin-motor drive are shown also in Fig. 3. As may be noted with the pinion drive, the spindles operate under the most favorable conditions when the rolls are close together. Usually, however, loads are heaviest when the ingot being rolled is large and the upper spindle considerably inclined. With twin-motor drive the spindle angle is at minimum when the rolls are separated considerably; hence with this type of drive the best operating conditions obtain when the load is at maximum.

Mechanically, the two motors of a twin drive are identical. The mill-end pedestal of each motor is supported on a heavily ribbed cast steel baseplate. The sides and front end of the bedplate are fabricated in the usual manner from heavy beams and slabs. The upper motor drives through a jack shaft, an "A" frame on the mill end of the lower motor supporting a pedestal bearing which carries the outer end of this shaft. Thrust in this jack shaft is taken care of by the mill-end pedestal of the upper motor. The lower motor is provided with the usual type of thrust bearing. Both the motor shafts and the jack shaft have forged flanges. Driving halves of the universal couplings next to the motors are bolted to the shafts in such a way that they can be removed for renewal or repair. Electrical construction of the motors is in accord with accepted practise for reversing service.

Characteristics of Twin- vs. Single-Motor Drives

Operating characteristics of the 10,000-hp. twin-motor drive are quite different from those of a conventional reversing equipment driving through pinions. These differences are indicated in the following comparisons.

1. Quieter operation.

Steel enters the rolls without shock. The usual vibration and noise in the mill spindles are absent, and there is practically no tendency for the mill to chatter. Consequently the roller is not required to exert the usual care but can enter the steel on the first trial, even at higher speed thereby saving time on the early breakdown passes.

2. Greater operating flexibility.

In the pinion drive, independent movement of the rolls is limited by the back-lash in the pinions and spindles: this limitation of movement constitutes the chief cause of roll chattering. With twin-motor drive the phase positions of the rolls can shift independently thereby quickly adjusting themselves to the steel and largely eliminating roll chatter.

3. Higher mill acceleration and retardation.

Comparatively low inertia in the motors allows the control to be designed for unusually fast field response without setting up high reverse power currents. Electrical equipment is therefore used to better advantage and the capacity for useful work is increased.

4. Intervals between passes reduced.

This is brought about by the rapid response of the motors which not only makes the handling of the drive much easier than the usual drive, but also permits the steel to be kept closer to the mill.

5. Total rolling time decreased.

The quick response of the motors increases the entering and average rolling speeds, thereby decreasing the rolling time by increasing the percentage of the time the metal is in the rolls.

Twin-motor drive also has been applied recently to the main horizontal rolls of a 44-in. slabbing mill. This mill is similar to that of the 54-in. blooming mill except that the total capacity of the drive is greater. The main horizontal rolls are driven by a 10,000-hp., 40/80-r. p. m., twin-motor drive similar to that just described. The vertical rolls are driven separately by a 2,500-hp. 79/225-r. p. m. 700-volt reversing motor. The flywheel motor-generator comprises three 3,500-kw. 700-volt generators but otherwise is the same as the blooming-mill set.

Twin Motors for Smaller Mills

The two installations just described are the first applications of twin-motor drive to heavy-duty mills and in addition represent the greatest power which so far has been applied to a single pair of rolls. For mills with 40-in. or smaller rolls requiring motor capacity of 8,000 hp. or less, the drive usually can be simplified by building each motor with a single armature. The smaller motors can be mounted on smaller centers and the spindle angles can be kept within reasonable limits without making the spindles excessively long.

It is possible from both the mechanical and electrical

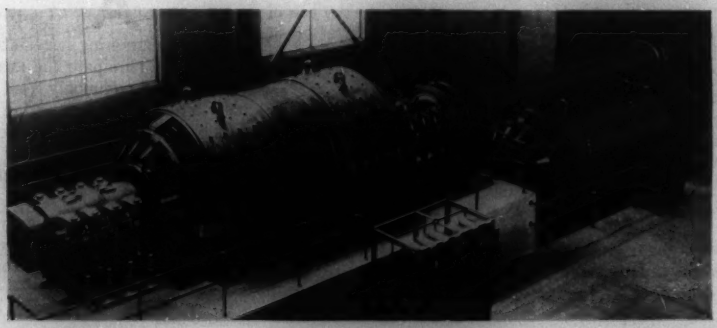

Fig. 4. General arrangement of the two 5,000-hp. double-armature motors as actually installed

standpoints to build a reversing mill drive with one motor on each side of the mill. With this arrangement small motor diameter is not an important consideration and the motors can be designed along conventional lines; where both motors are located on the same side of the mill, however, motor design may be somewhat special. However, within reasonable limits, electrical construction details are relatively flexible and each individual installation therefore should be laid out to fit local conditions most advantageously.

Cost and Other Considerations

Relative first costs of twin-motor reversing drive and pinion drive will vary with the size and torque requirements of the mill. The motors of a twin-motor drive with the necessary shafting and bearings are more expensive to build than a single motor of equivalent capacity. This increased cost may be somewhat less than the cost of a pinion stand with spare pinions and bearings for a heavy mill, but somewhat greater than these costs for a light mill. In general, however, the difference in cost is not great and is far outweighed by the many advantages of twin-motor drive.

Twin-motor drive offers advantages also for wide strip mills, whether these are used for hot or cold rolling. The chief advantage in this application is that the elimination of the mill pinions does away with the necessity for accurate matching of the mill rolls. When single-motor drive is used for either hot or cold rolling, unless the rolls are matched accurately, high stresses are set up in the pinions in order that the larger roll will slip and equalize the delivery speeds. With twin-motor drive the motor speeds readily adjust themselves so that each roll has the same surface speed. The problem of load division is quite simple, since wide thin material forms practically a perfect coupling between rolls.

The simplest form of drive for a strip mill is one having a direct-connected motor on either side of the mill, each motor driving one working roll. To this arrangement there may be objections, especially in hot-rolling mills, on account of the space occupied by the motor and spindles on the side of the mill usually left open. This objection can be overcome by the use of special gearing which will permit the installation of both motors on the same side of the mill. And since geared motors with pinion drive are now the usual thing, such an arrangement would introduce no new mechanical complications. The total number of gear units would remain the same, and instead of one reduction unit and one mill pinion unit, each of full capacity, there would be two reduction units, each of half the total capacity.

In recent years the conceptions of steel plant executives and engineers as to the expected output of various sizes and types of mills have become fairly well standardized. Certain standards also have been applied in selecting the electric drives. Where twin-motor drive is to be used, a revision of standards obviously will be necessary. Higher average rolling speed and the reduction of intervals between passes allow the capacity of such a mill to be increased over what would be expected from one with the conventional single-motor drive. The net result is a more advantageous utilization of electrical equipment in the twin-motor drive; hence a greater tonnage output can be realized with no increase in motor capacity. Moreover, in many cases it will be desirable to provide still greater motor capacity than now is customary in order to take advantage of every possibility for increased output.

A Vacuum-Tube Device for Current-Balance Telemeters

The motor-operated rheostat with its associated apparatus now is replaced by a simpler, more compact vacuum-tube arrangement. The only auxiliary power required can be obtained from an ordinary station-lighting circuit; circuit constants are chosen so that momentary dips in this supply voltage do not affect the readings.

By

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AN IMPROVEMENT for current-balance telemetering systems recently has been devised, not only to eliminate the auxiliary motor and special rheostat now commonly used with this apparatus but also to render unnecessary an additional source of d-c. supply. This new improvement utilizes electron tubes for producing and controlling the feeble direct current which constitutes the indicating medium for this type of remote metering.

In general, telemetering systems are capable of a wide variety of applications including not only measurements of electrical quantities but also of many mechani-

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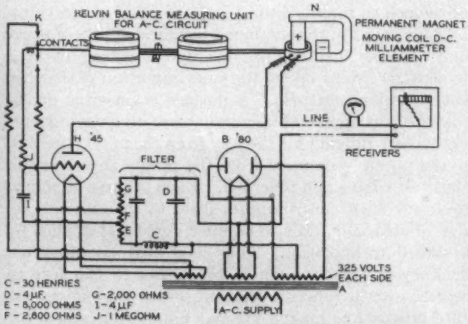
cal entities; for example, water-level indications in unattended hydroelectric stations. In the *current* type of apparatus as contrasted with other types the variations to be remotely observed are first translated into proportional currents; these are then transmitted over communication lines and measured at the remote receiving point by the usual type of current measuring instruments.

The current-balance system constitutes one particular species of current telemeter, utilizing a mechanism in which a direct current of *milliampere* magnitude is regulated to be proportional to the quantity being measured; this small direct current then being transmitted to the remote receiving point. As previously



Schematic diagram of new vacuum-tube transmitter for current-balance telemetering

constructed the transmitter in this system consisted essentially of a composite a-c.—d-c. balance mechanism in which the torque of a-c. measuring coils was balanced against the counter-torque of d-c. coils. Current in the d-c. coils was adjusted by a motor operated rheostat, the motor in turn being actuated by contacts on the balance mechanism.

A schematic diagram of the new electron-tube current-balance transmitter may be seen in the accompanying illustration. Power, voltage, current, or whatever entity is to be remotely indicated is applied to the measuring element *L* and produces a torque tending to close one of the contacts *K*. An electromagnetic counter-torque is established by the d-c. element *N*, which carries the telemeter current in the communication line, this of course being the current measured by the remote receiving meters. These two torques are applied against each other by the composite a-c.—d-c. balance mechanism *L-N*. If they do not balance exactly, contacts *K* operate to adjust the direct current (which is supplied from the plate circuit of tube *H*) to the balancing value. When the upper contacts close, the grid voltage of tube *H* is increased and the plate circuit is correspondingly reduced; when the lower contacts close, the grid voltage is reduced thereby increasing the plate current. The resistance *J* slows down the charging time of the condenser *I* enough to allow the balance *L-N* to open the contacts and stop charging when the proper current value is reached.

Power is obtained for the electron tubes and associated equipment from an auxiliary a-c. supply such as a station lighting circuit. Transformer *A* supplies filament voltages to both tubes, and plate voltage to rectifier tube *B*. This latter tube supplies the d-c. plate and grid voltages for tube *H* through filter circuit *C-D* and resistor *E F G*.

Resistances *E*, *F*, and *G*, are so chosen that *G-F* will produce enough grid voltage to reduce the plate current to zero, when voltage equivalent to the drop on *G* is impressed on the plate. The resistance *F* is so chosen that when a sudden change occurs in the line voltage of the auxiliary supply *A*, no change in the plate current of tube *H* takes place. Thus this resistor arrangement prevents line supply dips from showing on the record, and thereby overcomes a condition existing in previous forms of current-balance systems.

Use of electron tubes in this apparatus eliminates all moving parts used previously, excepting of course those associated with the meter elements. Accordingly the up-keep expense and attention required should be less than with the older type of transmitting system. Life tests made in the laboratory indicate also that under normal operating conditions radio tubes as used in this application should have an average life of much more than a year. In addition to the distinct advantages already mentioned, the apparatus is more compact than the motor-operated device and the currents which contacts *K* are required to handle are greatly reduced being only from 40 to 80 microamperes.

Clinical Sunlight—
Natural and Artificial

DISCOVERY of reasons for the well-known beneficial effects of sunlight on health has been a stimulus to efforts to produce artificial sunshine for use when and where natural sunshine is not available. Knowledge of the amounts of energy in various wavelengths of the solar spectrum throughout

From an article written by A. C. Downes, National Carbon Co., for *Research Narratives*, Dec. 15, 1930, published by the Engineering Foundation, Inc., 29 West 39th Street, New York, N. Y.

the year is necessary for production of the best artificial sunlight. Therefore measurements of sunlight in summer, fall, and winter, have been made at two sanatoria, in Ohio and Colorado, where sunlight has been used for years in treating disease. The physicians in charge in Colorado have found that noon winter sunshine has given the best results.

There are indications that several more or less clearly defined bands of the spectrum produce certain biological effects. Most clearly defined is the so-called antirachitic region (limited to wave lengths less than 3,100 Angstrom units), which is included in that portion of sunlight entirely removed by ordinary window glass. (The Angstrom unit is equal to a ten-millionth of a millimeter.) This band is responsible also for sunburn. The band of very short ultra violet (not present in sunlight) below about 2,800 Angstrom units is destructive to bacteria and molds. There are other bands which have specific biological effects but the evidence is not so complete as yet as for the two bands mentioned.

Carbon arcs have been produced closely approximating the amount of sunlight in more or less narrow bands at definite distances from the source, and some of these carbon arcs have been in use for the treatment of disease ever since Finsen began using the carbon arc at Copenhagen about 1895. Finsen's work has been continued by physicians all over the world using various types of carbon arc as well as other sources of light.

The carbon arc has been a useful tool to these investigators as, by the use of various metals and chemical compounds in the carbons, the quality of the light produced can be varied through a wide range. If light rich in the far ultra-violet entirely absent in sunlight as it reaches the earth is desired, the carbons are cored with iron or a combination of several metals such as iron, nickel, and aluminum. Carbons containing silver have been used to produce a strong band in the ultra-violet just above the so-called antirachitic band (2,900 to 3,100 Angstrom units).

Ideal artificial sunshine should have only the wavelengths present in natural light and in exactly the same proportions. At present no artificial illuminant has been produced which exactly duplicates sunlight in the distribution of energy in the various wavelengths, but a light which closely approaches sunlight in quality is given by an arc burning carbons cored or impregnated with salts of the rare earths. There are several chemical elements in these rare earths, but their effect on the light from the carbon arc is due principally to the metal, cerium.

An important property of any carbon arc is that the light emitted is dependent only upon the grade of carbon—that is, the kind and quantity of chemical elements used in the cores—and the current and voltage at which the arc is burned. The quality of the light therefore is independent of the lamp mechanism, but the quantity and direction of the light depend very greatly upon the efficiency of the reflectors and other features of design.

Coordination—
The Essence of Modern Engineering

By
WILLIAM S. LEE President A. I. E. E.

ENGINEERING ENTERPRISE has developed so rapidly from the application of individual technical skill to the combined technical efforts of many and variously qualified persons, that it seems propitious to consider briefly one of the most important of the present controlling features. A modern engineering undertaking of any appreciable size whatever involves influencing factors ranging all the way from the purely political to the purely economic; from the purely theoretical to the most simple and practical. Each of these factors of necessity must contribute its share to the ultimate design or structure, each to be interpreted and applied by a skilled technologist. Thus it is that coordination, hackneyed word though it be, comes to the fore as representing a function without which no engineering enterprise of any magnitude may hope to succeed in the full sense of that word.

Successful operation presupposes coordinated construction which in turn is dependent upon coordinated design, the whole enterprise resting fundamentally upon coordinated man power. The design of a modern complicated project represents the composite thought and combined experience of many minds so carefully blended, so well balanced, and so thoroughly interlocked, that each part will function and work in unison with every other part. Every project of any importance should be carefully designed in its entirety before very much if any of the construction work is undertaken. Only by this means may the construction engineer obtain the necessary insight into the ultimate purpose and use of the undertaking for which he is responsible, as well as the strength and character of each integral part, through which insight he may produce the desired results in the finished product. Only with a composite picture of the whole may the construction engineer proceed intelligently and meet modern economic limitations by building safely, quickly, and economically.

The achievement of a perfect structure in this day of broad and rigid requirements would be impossible without the assembled minds and the coordinated efforts of many kinds of engineers and technical specialists. In spite of this well-known fact, however, it is a common

An address delivered at the annual summer convention of the A. I. E. E., Asheville, N. C., June 22, 1931.

fallacy to look upon the result achieved as being the product of the efforts of one man. The really big man in engineering as well as in other professions is the simple man who readily recognizes and admits the fact that all major enterprises are fundamentally the products of well-directed group action. Very often the greatest and the most valuable man in a coordination conference is the man who can abandon his own ideas to espouse the cause of others in the interest of unified and effective effort.

In pausing for a moment to consider some practical examples we naturally turn to the field of electricity. One of the most perfectly coordinating forces in modern times is found in the transformation of energy into electric power and the application of this new form of energy into productive work. So perfect is the coordination that can be secured in the field of electricity that every phase of the almost innumerable detailed operations involved in a modern power plant may be so interlocked by electrical apparatus and so energized by electric power that they operate in perfect unison and always are ready with instantaneous response to the will of the operator in charge.

To cite another case of mechanical coordination, let us consider briefly the modern paper mill with which many of you are familiar. The real heart of this mill lies in the long line of rolls. These rolls are steam-heated and over them passes the paper as it evolves from a pulp to the finished product. Due to the fact that absolute uniformity of speed is required it was considered impossible until a few years ago to drive these rolls by any means other than spur gears. The electrical engineer, however, solved the situation by designing sensitive and accurate control equipment by means of which many electric motors may be electrically so interlocked as to maintain rigid synchronism. Thus these many independent motors turn the several rolls drawing the endless paper strips through them at a high speed, yet with a smoothness that avoids tearing even the most delicate paper.

As another example of coordinated effort consider the widely heralded Empire State Building in New York City. If prior to the completion of that structure you had visited the site and inspected the old building upon it, and had you been able to view the tremendous quantity of material of almost innumerable kinds that went into it, and then had been told just how long it would take to remove the old structures and assemble the raw materials into a new structure, you could have been pardoned for exhibiting grave doubt as to the possibility of accomplishing such a feat. Yet, as a result of strict coordination of design and construction, and the coordinated mobilization of the materials which had to be brought in piece by piece, that tremendous structure was completed within a phenomenally short time to its full height of 1,247 ft. above the sidewalk line.

The failure of the designing engineer or the construction engineer to coordinate their various related branches of engineering, construction, or specialization, can mean nothing but lost energy, lost time, and lost money in any great project.

In engineering, your mission, and mine, is far greater and more important then merely designing or constructing a great project. We must so synchronize the many kinds of engineering and the many kinds of materials involved that the finished product shall be perfect in its design, construction, and operation. In this connection it should be remembered specifically that the ultimate aim in every project is a perfect product rather than a perfect design. In the face of constantly increasing and ever more exacting demands in all kinds of engineering projects, we are training more engineers and more types of engineers year by year as specialists to refine and improve our general designs.

We must go further and maintain that initiative which builds the type of citizenship to which we owe our inventions, our developments, our progress—a citizenship far more valuable than the gold seams of arctic Alaska or the diamond fields of tropical South Africa—a citizenship that recognizes fully the fact that the only true equality in life is equality in opportunity.

In closing I wish to leave a message for the young engineer, and for the engineering student. It is my wish to impress these young men with the fact that opportunities still abound in the field of engineering in general, and electrical engineering in particular. True the specifications are somewhat broader and the requirements materially more rigid than they used to be; but to offset this, the young engineer of today has at his command a wealth of technological information nonexistent in earlier days. In my own opinion the wonderful field of coordination upon which I have touched but briefly now furnishes a new line of endeavor for you young engineers, and opens up a magnificent panorama of opportunity for service to yourselves and to your country.

If it were possible for Opportunity to stand before you today she doubtless would say:

"They do me wrong who say I come no more
When once I knock and fail to find you in;
For every day I stand outside your door,
And bid you wake, and rise to fight and win.

Wail not for precious chances passed away,
Weep not for golden ages on the wane;
Each night I burn the records of the day;
At sunrise every soul is born again.

Laugh like a boy at splendors that have sped:
To vanished joys be blind and deaf and dumb;
My judgments seal the dead past with its dead,
But never bind a moment yet to come.

Though deep in mire wring not your hands and weep;
I lend my arm to all who say 'I can!'
No shamefaced outcast ever sank so deep
But yet might rise again and be a man!

Dost thou behold thy lost youth all aghast?
Dost reel from righteous retribution's blow?
Then turn from blotted archives of the past
And find the future's pages white as snow.

Art thou a mourner? Rouse thee from thy spell!
Art thou a sinner? Sins may be forgiven;
Each morning gives thee wings to flee from hell;
Each night a star to guide thy feet to heaven."

News
Of Institute and Related Activities

Did you ever take a swim a mile up in the air? This is the famous mile-high beach at Lake Tahoe, California

Will You Take "Your Vacation at the Lake Tahoe Convention"?

A TECHNICAL PROGRAM second to none, in which many essentials of present-day demands upon electrical engineering will be set forth and emphasized; a diversive program of which golfing, dancing, feasting, outdoor sports and a multiplicity of other delighting holiday occupations will be the happy ingredients—these are some of the things in store for those who will heed the call and follow the injunction to "Make your vacation include the Tahoe convention;" joys which shortly will be linked irrevocably with recollections of the Institute's twentieth Pacific Coast convention to be held August 25-28, 1931, now bearing high promise of being "the best one ever." And who will not enjoy the climax of Wednesday evening August 26, with a real barbecue followed by a general meeting and subsequent entertainment?

Technical Program

With L. F. Leurey (M'27) of San Francisco in the chair, the technical sessions will open with the presentation of three papers devoted to the profession in industrial application. The second session presided over by S. J. Lisberger (M'11) chief engineer in charge of the division of electric distribution and steam engineering, Pacific Gas & Electric Company, will offer an interesting and instructive collation of facts on a-c. networks, the Mokelumne River development (by Mr. Lisberger's own company), line control of interconnected networks, and "tuned" power lines. Wednesday, August 26, with C. E. Fleager (F'26 and vice-president) chairman, will be given over to a new and detailed study of the ever active subject, communication; on this occasion from both community and intercontinental standpoints. In the evening, convention guests will be afforded the pleasure of listening to C. E. Grunsky, internationally known president of the American Engineering Council, who will address the convention concerning "business and economics," a subject never more vital than at the present moment.

The technical program will come to a

fitting close with Friday morning's session on electrophysics and general subjects including cathode drops in arcs and glow discharges, the kindling of electric sparkover, snow surveys, and radio coordination; R. W. Sorensen (F'19) professor of electrical engineering, California Institute of Technology, presiding.

Entertainment

As earlier paragraphs suggest, an ample program of entertainment has been searched out and perfected by diligent local committees. In addition to diversions already named, there will be held on Friday evening "A Night at Monterey," a gala celebration modeled after the Spanish fiestas of old. Tahoe Tavern and Lake Tahoe on the shore of which it is located are unexcelled for pleasures and beauty of surroundings. Tennis, swimming, golf, horseback riding, and an exceptionally fine bowling alley all are available within the Tavern grounds, while the Kit Carson Trail to the historic mining cities of Carson and Virginia City in Nevada offers a short, but ultra scenic trip. The usual tournament for the Fisken Cup, Pacific Coast A. I. E. E. golf trophy, will be played on the Tahoe course. The majority of interesting points may be visited with ease and comfort in less than a day's time for the round trip.

The ladies have been specially planned for of course; a boat ride to Emerald Bay, bridge parties, and automobile trips have been carefully arranged for all those interested in their participation. On the evening of Thursday, August 27, a short playlet will be staged "to provide fun for all"?

The "Night in Monterey" will be held for the most part upon the delightful and well-equipped beach and boardwalk, ably engineered by the management of the Tavern.

Vacation Suggestions

In line with the promise of the convention's part in vacation plans it should be remembered that Lake Tahoe is in the very heart of California's famous Sierra Nevada mountain range. In almost every direction trips upon the lake offer an entry into splendid mountain scenery. Yosemite Valley, the historic Mother Lode gold mining country, Sequoia and General Grant National Parks, and other attractive spots are daily reached by good roads from the main highways in central and southern California. Members coming from or through Oregon and Washington will find Crater Lake, the Oregon Caves, and the Coast highway through the famous redwood belt delightful and recreative.

Attractive convention rates will be made available to members and guests at Tahoe Tavern for the entire week of August 23 to accommodate those wishing to devote a few uninterrupted days to pure diversion.

Registration and Hotel Accommodations

A general information and registration desk will open in the lobby of the Tavern Monday, August 24, and delegates and guests are requested to call there as soon after arrival as possible to obtain badges and news of convention schedule. The following fees covering registration, banquet, all scheduled events, and greens fees for the golf tournament will be in effect:

Members and men guests	$5.00
Ladies	3.00
Student members	1.00
Student guests	2.00

Tickets for the Thursday evening banquet are for only those registering for the convention; this applies to members, men and women guests, enrolled students and student guests. Tahoe Tavern is offering special convention rooming rates to Institute members and their families attending the convention. Many of the exceptionally large rooms are suitable for groups of four or five, and better to accommodate the unusual number of persons expected the management hopes that those who care to take advantage of this club arrangement will make up their own parties and thus simplify the question of hotel space allotment. Convention rates including meals will be as follows:

Room or small suite with bath (shared by 1, 2, or 3) per person per day	$8.00
Room or suites with bath (shared by 4 or more) per day per person	7.50
Room without bath, per person per day	7.00

All reservations must be made through the hotel committee by means of the regular hotel reservation blank provided; registrations made direct with the Tavern will not be recognized to benefit by convention rates. Order of receipt will establish precedence of choice of accommodations, etc.

The Fisken Trophy

The John B. Fisken Cup, much coveted golf trophy, is awarded annually to the best tournament score among members of the Pacific Coast Sections from 18-hole medal play at handicap. Many other prizes also will be awarded, all of which should make the tournament a feature attraction to any enthusiastic registered delegate or guest. No greens fees will be charged for the tournament, but specific information establishing handicap, etc., should be returned with the registration card.

Transportation

Excursion rates are available from all points, railroad service to Lake Tahoe being provided by the Southern Pacific Company via its Overland Route. Spe-

Tahoe Tavern, headquarters of the forthcoming Pacific Coast convention

The annual tournament for the John Fisken cup will be played among the pines of the majestic "High Sierra"

cial routing information for making the trip by auto travel through most historic and scenic territory is made available by The Pacific Gas & Electric Company which will arrange to have its local representatives along all routes to the Lake to furnish specific information and render any possible service in case of emergency.

COMMITTEES

General convention committees and officers serving in the various departmental divisions of convention activities are as follows:

Chairman, A. W. Copley (F'26); vice-chairman, P. B. Garrett (M'30); both of Westinghouse Electric & Mfg. Company, 1 Montgomery Street, San Francisco, Calif.; secretary, E. F. Maryatt (M'27) of the Pacific Gas & Electric Company, 245 Market Street, San Francisco, Calif. Committee chairmen include A. G. Jones (A'07) *entertainment;* E. A. Crellin (F'28) *finances and hotel;* A. V. Thompson (A'23) *golf;* F. R. George (M'25) *inspection trips;* W. C. Heston (M'20) *publicity;* M. S. Barnes (A'18) *registration;* C. E. Fleager (F'26 and vice-president) *reception;* D. I. Cone (M'24) *technical program;* S. G. Palmer (A'15) *student activities;* P. Lebenbaum (M'13) *transportation;* and Mrs. Hector Keesling, *ladies' entertainment;* assisted by C. E. Carey (M'25), H. B. Carpenter (F'18 and vice-president), J. N. Chamberlain, L. B. Fuller (A'03), L. F. Fuller (F'23), A. V. Guillou (M'27), J. Hellenthal (M'23), H. W. Hitchcock (M'27), G. L. Hoard (A'19), A. H. Kruel, P. J. Ost (M'23), W. C. Smith (M'26), and L. A. Traub (A'28), members of the local committee.

Technical Program

Tuesday, August 25

10:00 a. m. Industrial Applications—L. F. Leurey, chairman.

ELECTRICAL POWER IN WOOD PRODUCTS INDUSTRY, by C. E. Carey and K. L. Howe, Westinghouse Electric & Mfg. Company, Seattle, Wash.

APPLICATION OF ELECTRICITY TO OIL FIELD OPERATION, by H. C. Hill and J. B. Selegue, Los Angeles

CORRELATION OF INDUCTION MOTOR DESIGN FACTORS, by V. Hoover, Teaching Fellow in E. E., California Inst. of Tech.

2:00 p. m. Power Transmission and Distribution—S. J. Lisberger, chairman

ECONOMICS OF A-C. NETWORKS FOR SECONDARY DISTRIBUTION, by S. B. Clark, Portland, Ore.

THE MOKELUMNE RIVER DEVELOPMENT OF THE PACIFIC GAS & ELECTRIC COMPANY, by E. A. Crellin, E. M. Wright, and B. D. Dexter, Pacific Gas & Elec. Company, San Francisco, Calif.

TIE-LINE CONTROL OF INTERCONNECTED NETWORKS, by C. A. Powel, Westinghouse Elec. & Mfg. Company, and T. E. Purcell, Duquesne Lt. & Power Company, Pittsburgh, Pa.

TUNED POWER LINES, by H. H. Skilling, Stanford University

Wednesday, August 26

9:30 a. m. Student Technical Session No. 1

2:00 p. m. Communication—C. E. Fleager, chairman

INTERCONTINENTAL TELEPHONE SERVICE, by J. J. Pilliod, engineer, American Tel. & Tel. Company, New York, N. Y.

ELECTRICAL SOLUTIONS OF PROBLEMS OF REGULAR SCHEDULED FLIGHT, by C. F. Green, Schenectady, N. Y.

THE SAN FRANCISCO-LOS ANGELES SECTION OF THE PACIFIC COAST TELEPHONE CABLE NETWORK, by E. M. Calderwood, San Francisco, and D. F. Smith, Los Angeles, both of the Pacific Tel. & Tel. Company

ELECTRICAL SOUND-ABSORPTION MEASUREMENTS, by A. L. Albert and W. R. Bullis, Corvallis, Ore.

Evening

Barbecue dinner

Address by C. E. Grunsky, president of American Engineering Council "Business Cycles and Some Economic Problems"

General meeting followed by entertainment

Thursday, August 27

8:00 a. m. Student Breakfast and Conference

Afternoon

Sports

Evening

Banquet and playlet

Friday, August 28

9:30 a. m. Electrophysics and General Subjects—R. W. Sorensen, chairman

CATHODE DROP IN ARCS AND GLOW DISCHARGES, by S. S. Mackeown, California Institute of Technology, Pasadena, Calif.

THE KINDLING OF ELECTRIC SPARKOVER, by C. E. Magnusson director of engineering experiment station, University of Washington, Seattle

SNOW SURVEYS, by H. P. Boardman, professor of C. E., director of engineering experiment station, University of Nevada, Reno

RADIO COORDINATION, by H. N. Kalb, Great Western Power Company, and C. C. Campbell, Pacific Gas & Electric Company, San Francisco

Irrigation Waste to Run Texas Plant

A hydroelectric plant to be built by the Central Power & Light Company near Eagle Pass, Texas, will utilize waters returned from the Maverick County Irrigation District No. 1, after they have been diverted for irrigation purposes and carried back by a supply canal to penstocks.

Excavations for the power house of this plant were started May 23, 1931; it is expected that the plant will be ready for operation early in 1932. The generators will be of 3,500 kw. 6.9 kv. umbrella type, the power produced to be transformed to the higher voltages in an adjacent substation. A 66-kv. line coming from the East supplies power for construction now and will be used later to carry power to the operating company's other points of distribution. During the irrigation season the river flow amounts to approximately 1,000 sec-ft. but at certain other seasons it reaches a 1,500 sec-ft. volume—*Wendell C. Fowler, San Antonio Section Correspondent.*

Asheville Convention Closes Busy Institute Year

WITH more than 500 persons in attendance the Asheville convention proved a fitting climax to a busy year. Essentially every District and active Section throughout the United States and Canada and including Mexico City, were represented It was of particular interest to note the high percentage of women guests who attended from distant points giving color and lending charm to an affair already under the spell of hospitality so typical of the Old South.

Importance of District Meetings Stressed

In a prelude to his final formal address before the Institute President Lee emphasized again his fervent wish to "Take the Institute to the members instead of trying to bring the members to the Institute." In this connection he emphasized the increasing value of District meetings, urged every effort to develop them, and outlined current progress in that direction. President Lee also called attention to the great value of the younger members to the Institute and of the Institute to the young electrical engineer, urging a greater participation on the part of the younger men. In his formal address, full text of which appears elsewhere in this issue, he sounded a challenge and a distinct note of encouragement to engineering students.

Delegates Sessions Well Attended

Two particularly well attended sessions of delegates, officers, and members were held at which several subjects of particular import to Institute members were rather fully discussed. These included the licensing of engineers, membership problems including transfer qualifications, and Section and student Branch operating problems. More concerning all of these subjects will be presented in Electrical Engineering as the various committee studies and reports are completed. Technical sessions all were very well attended, attendance being enhanced perhaps by the fact that many of the sessions were held on the open verandas of the Grove Park Inn overlooking the North Carolina mountain scenery. A brief outline of the several papers presented is given in the paragraphs that follow; discussion will be reviewed in a subsequent issue.

Interconnections Discussed and Evaluated

RECOGNITION of some of the technical problems involved in the present-day trend toward mergers and large cooperative undertakings in the field of the electric service company, an entire session of the Asheville summer convention was devoted to a symposium of four papers on this general subject.

In his paper relating to the classification and evaluation of interconnection services A. E. Bauhan (M'17) of the Public Service Electric & Gas Company, Newark, N. J., defined his interpretation of the word *interconnection* as meaning the physical tying together of two or more independently owned or separately managed electric systems for the purpose of realizing financial benefit or service improvement through the interchange of power.

Under the heading of service classification the author listed emergency service, load diversity, firm power, storage power, intra-company use, economy flow, and unintentional flow. He expressed the hope that these seven suggested classifications would form the basis of discussion and experiment which would lead eventually to a generally acceptable classification and nomenclature.

Economic Evaluation

After defining and describing these classifications in some detail, Mr. Bauhan launched into a discussion of interconnection service evaluation, stating that such evaluation represented the economic basis upon which the desirability of a proposed interconnection should be made. He stated that the services previously mentioned may be evaluated as to capital cost by determining the aggregate saving in the cost of generating capacity, and then comparing the result with the capital cost of the interconnection itself.

Stating that "interconnection is only one of the many factors contributing to the accomplishment of the purpose of the electric utility industry," G. M. Keenan (F'29) superintendent of the Penn-New Jersey Interconnection (Hazleton, Pa.) pointed out that the "possibilities of interconnection can be realized only when the system is effectively developed and operated."

Diverse Interests of Participants Must be Coordinated

Mr. Keenan emphasized the limiting feature represented by the fact that while interconnected systems operate as a unit, the companies owning them have diverse interests which must be sufficiently coordinated to make available to all participants the maximum benefits to be realized by interconnection. Mr. Keenan stated also that interconnection development usually tends to reduce generating costs at the expense of increased transmission costs and hazards, concluding that "possibly there are some limits to the size of the interconnected system and the degree of coordination desirable between ownership."

The interconnected system representing ten independent operating companies of western Pennsylvania, eastern Ohio, West Virginia, and Maryland, were described at some length by H. S. Fitch (A'18) of the West Penn Power Company, Pittsburgh, whose paper reflected the operating practise and experiences of that group. He described the territory served by these companies and outlined the benefits derived by the interconnection as including a reduction in spare capacity, investment and operating economies effected through (1) dovetailing of construction programs; (2) joint financing of power stations and transmission lines; and (3) noteworthy protection of service continuity.

Disadvantages More Than Offset by Benefits Derived

E. W. Dillard (M'30) and W. R. Bell (A'15) of the New England Power Engineering & Service Corporation, Boston, Mass., described in some detail the various practical problems involved in a typical New England interconnection involving systems in parts of six states. After outlining the history and development of the various interconnections, the authors gave as the objectives of their system the following:

1. The absorption of surplus hydro power from systems generating largely from unregulated hydro sources.
2. The absorption of large quantities of surplus steam with resultant good load factor on relatively high-grade steam plants of adjacent systems.
3. Arrangements for the purchase of surplus steam capacity in various stations which resulted in a certain amount of firm capacity.
4. The sale or purchase of firm power.

The authors outlined in some detail the benefits derived from these various factors, described the contractural relations entered into in the various cases, and pointed out certain disadvantages and difficulties encountered. They stated definitely, however, that they "do not believe that any disadvantages have come about in any New England interconnection that are not offset entirely by benefits derived."

Transients Important in Electrical Machine Design

ELECTRICAL machinery and its design and operating characteristics, always of interest in Institute conventions, were no exception at Asheville. This time the subject of electrical transients seemed to dominate in all presentations and discussions.

The problem of reestablishing excitation of a loaded alternator operating in parallel with others was discussed at some length by D. D. Higgins (M'27) and E. Wild (A'27), both of the Commonwealth Edison Company, Chicago. The authors described tests performed with large turbine-generators operating under load, and gave a résumé of various answers to a questionnaire bearing upon the phenomena accompanying the interruption and reestablishment of a generator's d-c. excitation. As a result of their investigation the authors conclude that the reexcitation of a generator without removing it from the bus is a justifiable and safe operating procedure and one which will restore all conditions to normal in the shortest time.

Reactance and Time Constants Calculated

L. A. Kilgore (A'29) of the Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa., presented a highly mathematical dissertation pertaining to a method of calculating reactance constants and time constants, as they affect transient characteristics of synchronous machines. The author pointed out that recent theoretical advances have introduced many new constants; also that most of the discussions on such constants published previously have been concerned with the *application* rather than the *calculation* of the values involved. In his paper Mr. Kilgore calculated the more significant constants and gave comparisons between tests and calculated values to support the accuracy of his method. In two extended appendices he gave formulas for salient-pole machines and turbine-generators, and pointed out that because of differences in construction many of the formulas for turbine-generators are different from those for salient-pole machines. He discussed the more important differences.

As a companion paper to Mr. Kilgore's, S. H. Wright (A'29) also of the Westinghouse Company presented an extensive treatise descriptive of the determination by test of synchronous machine reactances, resistances and time constants. The author emphasized the practical side of the situation basing his statements and conclusions upon observations made from many tests and their results. Mr. Wright considered three classes of synchronous machines—turbine-generators, salient-pole machines with dampers, and salient-pole machines without dampers. In his tests the author achieved saturation effect under short circuits by applying short circuits to machines operating at rated voltage. He discussed in some detail the more important of the variable saturation effects, and by defining certain saturation and other values attempted to provide a definite basis for the practical specification of machine constants.

Transformer Transients Affected by Many Factors

An essentially mathematical study of transient voltages in transformers and similar equipment was presented by L. V. Bewley (A'27) of the General Electric Company, Pittsfield, Mass. Mr. Bewley devoted his major effort to showing the effects on voltage distributions of wave shape, circuit constants, and neutral impedances, and in describing methods by which the voltage distributions may be controlled or varied. He derived a general differential equation for a circuit consisting of distributed self- and mutual-inductance, series and shunt capacitance, series resistance and conductance along the stack to ground. The author presented (1) numerous solutions of his equation covering various sets of conditions; (2) equations corresponding to many different applied waves showing the effects of wavelengths, wave front, etc.; (3) equations for calculation of potential difference or voltage gradient between points in windings; and (4) tables showing the influence of various circuit constants on wave characteristics.

In describing field transients in magnetic systems, Ernst Weber (A'31) of the Brooklyn (N. Y.) Polytechnic Institute gave a comprehensive mathematical solution of the situation arising from the sudden application of a d-c. voltage through an electromagnetic circuit containing a partly laminated and partly solid iron core with an air gap. Ranging in mathematical manipulations from Maxwell's field equations for eddy currents and magnetic field in an iron core to Heaviside's operational calculus, the author achieved results which he expressed by means of a time constant of the magnetic field. In discussing the practical application of his results the author gave a numerical example and called attention to the effectiveness of quick response excitation for improving electric system stability under short circuit conditions, particularly where large synchronous generators are involved.

Efficient Communication Facilities Required for Successful Operation

REFLECTING the important position occupied by communication facilities in the successful operation of a modern electric light and power system, a symposium of five papers dealing with important phases of the subject occupied one entire technical session of the Asheville convention. Nine different authors collaborated in the preparation of these papers representing some five different power systems and three different divisions of the Bell Telephone System.

In practically all cases the three major divisions of communication service that received specific attention were those pertaining to (1) operating activities including dispatching, plant and substation operation, line patrol and repairs; (2) customer service activities including new installations, disconnections, transfers and service complaints; and (3) administrative activities including executive, sales, and business functions as differentiated from the service functions.

Principal Requirements Outlined

Fundamental considerations underlying the planning and providing of adequate and economical communication services for electric utilities were rather fully outlined and briefly discussed in a paper prepared by R. N. Conwell (F'31) of the Public Service Electric & Gas Company, Newark, N. J., G. M. Keenan (F'31) superintendent of the Penn-New Jersey Interconnection, Hazleton, Pa., C. F. Craig (M'27), special representative of the American Telephone & Telegraph Company, New York, and E. C. Briggs of the Ohio Bell Telephone Company, Cleveland. These authors described the normal workings of an electric utility as

being so divided that all three classes of communication service mentioned in the preceding paragraphs are required. In enlarging upon the subject of communication facilities for operating activities, they stated that such facilities needed to be:

1. Easy to operate and capable of establishing prompt communication connection.

2. Available at times when generating and distribution facilities are in trouble.

3. Of sufficiently good quality to avoid misunderstandings and to permit conversations to be carried on with ease.

4. Adequately protected from the safety standpoint but not to a degree that would interfere with communication service during electric service difficulties.

5. Of sufficient capacity to obviate serious delay even under emergency conditions.

Leased Lines Preferred to Carrier Systems

E. S. Bundy (M'30) of the Buffalo (N. Y.) Niagara & Eastern Power Corporation, described the communication facilities of the western division of the Niagara-Hudson system. He characterized the modern tendency of interconnecting electric generating and transmission systems as leading to systems covering "such large areas that the communication lines have become almost as important as the power lines themselves."

Mr. Bundy described the communication requirements of his system which include remote metering, system dispatching, load supervision, commercial business, and ordinary interdepartmental communication. Perhaps the most important communication service in that system is provided by lines leased from the telephone company, arranged in some cases so that conferences involving several persons may be held over the lines. Single-frequency duplex carrier-current installations providing two-way communication between eight of the more important stations on the consolidated system supplement the line service. Under normal operating conditions leased lines are used in preference to the carrier system because of the better quality of transmission.

A description of the communication needs of a power company serving a large metropolitan area was given by P. B. Juhnke (M'20) of the Commonwealth Edison Company, Chicago. Detailed information pertaining to load dispatching problems on his system were discussed, and the use of remote metering facilities as an effective aid in conducting load dispatching operations was described. On this system the technical group in the load dispatching office is in direct private wire communication with all generating and distribution stations, and with most substations. In describing his remote metering system Mr. Juhnke mentioned that metallic telephone circuits now are used exclusively but stated that since telemetering impulses now can be transmitted over carrier-current communication systems, the usefulness of such carrier systems has been enhanced materially.

Coordinated Systems Most Economical

C. A. Booker of the New England Power Association, Boston, and M. E. Clark of the New England Telephone & Telegraph Company, Boston, described at some length a cooperative study of power system communication conducted jointly in New England by the power company and the telephone company. The problems there encountered involved a survey of existing communication facilities in the several districts effected, the determination of present and future communication requirements, and the analysis of these requirements to ascertain what improvements, changes, or additions should be made. Coordination of existing facilities both on the Bell system and on the Power Association's various private lines was the watchword of the joint investigation.

Switching from the communication problem of the relatively closely knit interconnected system to that of the relatively far flung interconnected system, E. C. Stewart of the Arkansas Power & Light Company, Pine Bluff, Ark., described the communication system in use on the Arkansas - Louisiana - Mississippi Interconnected Power System. Long distances between stations are the regular order of affairs on that system, and as a result carrier-current telephone equipment is used to a large extent, the longest distance so served being 459 mi.

After outlining the history of development and describing the problems incident to the development of the carrier-

"The Engineer Views Hopefully the Hitherto Unattainable"

SUCH is the message of the Lamme Medal established by a bequest of Benjamin Garver Lamme, chief engineer of Westinghouse Electric & Manufacturing Company, who passed away July 8, 1924, after a life of professional usefulness. According to provisions of the bequest, a gold medal accompanied by a replica in bronze goes in award each year to a member of the Institute "who has shown meritorious achievement in the development of electrical apparatus or machinery." William J. Foster, D. Sc., consulting engineer (retired) of the General Electric Company, Schenectady, N. Y. was this year's recipient (see p. 230, Electrical Engineering, March 1931). A similar bequest was made by Mr. Lamme to Ohio State University, by which annual award is made to a graduate from any of its engineering branches "for meritorious achievement in engineering or the technical arts;" while a third medal is awarded by the Society for the Promotion of Engineering Education "for accomplishment in technical teaching or actual advancement of the art of technical training." The first Lamme Medal to be awarded by the Institute (1928) was given to Allen B. Field (F'13) consulting engineer, Manchester, England; the second to Rudolph E. Hellmund (F'13) chief electrical engineer, Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa. C. E. Skinner, assistant director of Engineering, Westinghouse, received this year's award from Ohio State. (See p. 519 of this issue.)

current system, the author related some operating experiences. He said "the carrier-current installation on the interconnected system, supplemented by the use of toll service, and one or two leased or specially arranged circuits, is primarily for use by the dispatcher, but considerable business traffic is handled by the dispatching force outside of any rush period."

Automatic Control is Proving its Merit

CONCERNED with the general subject of automatic equipment five papers were presented at an Asheville session. Two of these dealt with the details of supervisory systems for electric power apparatus, one dealt with automatic combustion control, and two presented rather comprehensive outlines of actual operating experience with automatic and supervisory control equipment.

R. M. Stanley (F'23) of the Byllesby Engineering & Management Corporation, Chicago, Ill., described briefly the miniature switchboard supervisory automatic control equipment installed at the Ohio Falls Hydroelectric Station at Louisville, Ky., and gave a résumé of three years' operating experience with that equipment. Mr. Stanley gave the engineering reasons for the adoption of miniature supervisory switchboard and automatic control as being a desired reduction in capital expenditure, and reduced fixed and operating charges. As a result of his experiences he has concluded that automatic devices greatly enhance the services of a capable operator, and produce better station operation than would be possible by a manual system of control alone.

Inspection and Maintenance Important Items

In a jointly prepared paper Garland Stamper (A'25) of the Columbia Engineering & Management Corporation, Cincinnati, Ohio, and F. F. Ambuhl (M'26) of the Toronto Hydro-Electric System, Toronto, Ont., Canada, described their respective operating experiences with automatic station and supervisory equipment. Mr. Stamper stated that the Columbia system has had automatic and semi-automatic stations of various types in operation for the past ten years, and as a result of experience stated emphatically that the degree of satisfaction secured in the operation of any type of automatic equipment is directly dependent upon the quality of inspection and maintenance.

Mr. Ambuhl reported that on the Toronto system automatic controls have given fairly satisfactory results and the supervisory controls have given excellent results, especially the cable-type supervisory." Relay failures constitute the chief source of trouble mentioned.

An a-c. supervisory control system devised to accomplish all that the more common d-c. supervisory systems now do, was described by O. K. Marti (M'27) of the American Brown Boveri Company, Inc., Camden, N. J. The equipment was said to be independent of interruptions in the a-c. supply at stations where it was installed, since it depends upon a small motor-generator set driven from the station battery. For this system five wires between stations are required, two being common supply lines, one a synchronizing wire, one a control wire, and one an indication wire.

Centralized Control Important in Railway Electrification

The Pennsylvania Railroad in its electrification in and around Philadelphia has made use of two installations of supervisory control for the remote operation of high-voltage a-c. step-down substations supplying energy to its traction system. The equipment used and the system involved were described by C. P. West (M'28) of the Westinghouse Electric & Manufacturing Company, East Pittsburgh, and H. C. Griffith of the Pennsylvania Railroad Company, Philadelphia, who stated that the normal practise of the railroad has been to install substation control in signal towers adjacent to substation location, because most substations have been near 24-hr. signal towers. Conditions are changing, however, and the system is expanding beyond the normal operating radius of signal towers. The authors state that from the many advantages of centralized control, this method is destined to play an increasingly important part in future railroad electrification.

Automatic Systems for Accurate Combustion Control

Since heat-power plants have increased so enormously in size, and combustion practise reduced so nearly to an exact science, automatic combustion control has become an economic necessity according to C. H. Sanderson (F'18) and E. B. Ricketts of the New York Edison Company, who presented a joint paper describing several of the more important automatic combustion control systems. The authors cited as being among the important advantages: (1) the uniform loading of all boiler units; (2) instant response to changes in load; (3) correct proportion of fuel and air supply at all times; and (4) a ready means of providing for safety in operation through sequence interlocking of auxiliary equipment.

High-Voltage Cable Practise Continues to Advance

IN an Asheville session devoted exclusively to the subject of cables, the discussions presented ranged all the way from the most highly theoretical to the most practical. Three research workers, four manufacturers, and one prominent operating man presented papers representing their various fields of interest and thus contributed to a better general understanding of the subject.

Results of still further study on the open question hinging on the influence of residual air upon cable insulation life, were presented in a paper by J. B. Whitehead (F'12) and F. Hamburger, Jr. (A'26) of Johns Hopkins University, Baltimore, Md.,—their third A. I. E. E. paper on that subject. As a result of their intensive investigation, the authors have concluded among other things that:

1. The life of impregnated paper insulation increases steadily with a decrease in the amount of residual air.

2. For impregnating pressures above 2.5 cm. the life decreases rapidly with increasing pressure of impregnation. For pressures below 2.5 cm. the results show an increase of life of from 10 to 50 per cent between 2.5 cm. and 2 mm. impregnating pressure.

3. For impregnating pressures below 2.5 cm., normal variations in material and structure, particularly in the tightness of the structure, may offset the increased life due to decreasing the pressure of impregnation.

4. Cable compound deteriorates if it contains only a small amount of air even though kept in sealed containers, at room temperature. To avoid deterioration air should be entirely excluded.

5. Flat power-factor voltage curves and the absolute value of power factor should not be accepted as indications of long life.

6. Power-factor rise due to the initial application of voltage during a life test is indicated as a possible criterion of insulation life.

7. A very satisfactory type of sample and a reenforced end for accelerated life tests have been developed.

8. Narrow variations in the quality of both paper and oil may cause wide differences in the electrical characteristics and in the lives of the impregnated products.

Insulation Variability Limits Allowable Operating Stresses

M. C. Holmes (A'26) of West Virginia University, Morgantown, presented a paper describing a method of analyzing the effect of insulation variability in the determination of breakdown voltages and allowable operating stresses. He emphasized the necessity of considering the variability as well as the so-called strength of insulation and quoted terms of allowable operating stresses and failures in support of his contentions. He developed and discussed the application of a general equation, giving in terms of two parameters the breakdown voltage and the number of failures to be expected, the mean breakdown voltage, and the variability of insulation.

Oil-filled cables and accessories were described by R. W. Atkinson (F'28) and D. M. Simmons (F'28) of the General Cable Corp., New York, N. Y., who defined the term "oil-filled" as being ordinarily understood to indicate a cable in which the compound is of such viscosity as to be fluid at all operating temperatures.

General theory and some of the outstanding characteristics of oil-filled cable practise were discussed in some detail by G. B. Shanklin (M'29) and F. H. Buller (M'29) of the General Electric Company, Schenectady, N. Y.

Better Cables at Lower Costs Predicted

An illuminating and fairly comprehensive outline of economic high-voltage cable practise based upon extensive research and intensive practical application was given by D. W. Roper (F'14) of the Commonwealth Edison Company, Chicago. In illustrating the salient points of his discussion Mr. Roper presented numerous data and diagrams. He called upon utility companies to improve their standards of design and workmanship to keep pace with cable improvements effected by manufacturers. He stated definitely that in his opinion the present rate of improvement in the art of high-voltage cable practise would continue in succeeding years, and further in prediction said that:

1. Cables of all types and voltages will be operated at maximum temperature of from 85 to 90 deg. cent. without fear of deterioration.

2. Extensive oil reservoirs and accessories on oil-filled cable will be eliminated.

3. An installation of oil-filled cable will be no more complicated than a present day installation of ordinary cable.

4. Cable of subnormal quality will be eliminated by factory tests.

5. Initial costs per kva. of 66-kv. cable completely installed will range from 30 to 40 per cent lower than the present cost of ordinary cable.

6. Cable failures due to all causes will not exceed one per 100 mi. per year.

Standardization of Units an International Problem

ELECTRICAL units, their modernization, international standardization, precise determination, and proper application is a subject occupying a great deal of the time of many learned technologists throughout the world. Advancement in the art and science of electrical engineering has given rise to a rather concerted study of electrical units along the lines as just indicated, to say nothing of international effort to arrive at a logical and representative nomenclature. Reflecting the importance and timeliness of the subject, the fourth session of the Asheville convention was devoted to a symposium of four papers on various phases of the subject.

H. B. Brooks (F'31) of the Bureau of Standards, Washington, D. C., treated at some length the unit of electrical resistance, going into its past history, and outlining impending changes. The author described the mercury ohm as having been so long legalized as a material standard of resistance that it is regarded widely as a permanent institution of relatively precise proportions, but stated that practically it is obsolescent because of the technical difficulties attending its use. The author further characterized the mercury ohm as a necessary but expensive evil holding its place because formerly it could be reproduced more precisely than could the agreement between the results of absolute determinations of the ohm. He concluded his presentation saying that the technique of absolute determination has improved until now it may be said to be at least on a par with the mercury ohm as to reproducibility. Consequently this method should be used to obviate the laborious and time-consuming effort of high grade men now going into repetitions of mercury ohm determinations.

Standards Must Keep Pace with Advances in Equipment

In a discussion of electrical units and their application, L. T. Robinson (F'12) of the General Electric Company, Schenectady, N. Y., emphasized the necessity of providing for the advancement of precise definitions and precision standards to keep pace with contemporary advances in equipment. In speaking of the importance of accurate measurements as far as scientific advance is concerned, he said "progress and improvement are made possible only to the extent that those interested in and working along the line of developing and improving measuring methods and instruments are able to anticipate the needs of those interested in the development and operation of systems, devices, and apparatus."

Pertaining to the international standard of electromotive force, and its low-temperature coefficient form, Marion Eppley (M'31) of the Eppley Research Laboratory, Newport, R. I., described at some length the great difficulty in achieving the physical conditions prescribed in the officially agreed upon fundamental definitions of certain electrical units. He described briefly several different types of so-called standard cells for reproducing physically a standard volt, discussing also various tests made on and the characteristics of the cells. He concluded definitely that his fifteen years of work on the cadmium cell have given him "ever increasing confidence in its reliability," even if it "is by no means foolproof."

Laboratory Potentiometers Discussed in Detail

Information pertaining to the design of d-c. laboratory type of potentiometers was given by I. M. Stein (M'27) of the Leeds & Northrup Company, Philadelphia. The author treated his subject under the following ten headings: (1) early history; (2) factors affecting voltage range; (3) factors affecting potentiometer resistance; (4) low-voltage potentiometers; (5) analysis of potentiometer errors; (6) self-checking features of potentiometers; (7) galvanometer considerations; (8) comments on volt-boxes; (9) deflection potentiometers; (10) the potentiometer in industry.

Research Problems Vie with Cooperative Education

COOPERATIVE educational methods competed with transmission stability research problems for the attention of those attending the closing session of the summer convention.

D. C. Jackson, Jr. (F'30) of the University of Kansas, discussed in some detail the application of the cooperative method of instruction to engineering schools and

polytechnic institutes. As constituting five important factors governing the application of the cooperative method to any given institution, the author considered (1) the size, (2) geographical location, (3) type of location, (4) method of support, and (5) organization of the institution. He discussed various methods of applying the cooperative plan and expressed the opinion that "no exact conclusion can be drawn concerning the general principles governing the installation of the cooperative method at an institution since the controlling conditions are so different in each case."

Factors Affecting the Extinction of Short A-C. Arcs

The results of a study concerning the extinction of short a-c. arcs were discussed in a paper by T. E. Browne, Jr. of the Westinghouse Elec. & Mfg. Company, East Pittsburgh, Pa. Mr. Browne's findings as stated were:

1. That the arc space recovers the ability to withstand 100 volts or more within a few microseconds after a current zero, as predicted by Slepian's theory.

2. That the maximum allowable rate of voltage rise across the arc space which will just permit arc extinction, is much greater for very short arcs (1 cm. or less) than for longer arcs.

3. That the critical rate of voltage rise depends upon the electrode material and tends to vary as a decreasing linear function of the boiling point of that material.

4. That the higher-current arcs have a much lower critical rate of rise of voltage than the lower-current arc.

Vacuum Tubes Score Again

A corona-tube voltage regulator designed to accomplish all of the functions of the ordinary vibrating type of regulator, and without the mechanical difficulties incident to the latter, was described by H. W. Dodge of the New Jersey Bell Telephone Company, and C. H. Willis (M'28) of Princeton University. The authors presented and described a circuit wherein a corona tube is used to regulate the output of a full-wave rectifier, the rectifier in turn controlling the excitation of a generator to give constant voltage. They presented very attractive performance curves covering the application of the apparatus to a 5-kva. generator under varying load conditions. The authors characterized the regulator as employing the same methods of compounding and line-drop compensation now in use and expressed the belief that the simplicity, compactness, high sensitivity, and quick response of the regulator offered important advantages.

Lightning Surges Cause Arcing Faults

Experimental studies of arcing faults imposed on a typical 75-kv. transmission system were discussed in a paper prepared jointly by J. R. Eaton (A'27) of the Consumers Power Company, Jackson, Mich., J. K. Peck (A'27) of the National Electric Light Association, New York, and J. M. Dunham (A'31) of the American Telephone and Telegraph Company, New York. High-voltage impulses simulating lightning were imposed upon an energized transmission line to cause flashovers. As a result of their observations the authors concluded that the probability of a lightning flashover causing a power arc is increased when power current is flowing past the flashover point, when the normal frequency voltage is increased, or when the normal insulation is decreased.

Effective arc resistance was described as being approximated by the ratio of the peak voltage to the peak current, the apparent power factor of the arc current and voltage being practically unity in most cases. The tests showed that arcs formed in a capacitive circuit are more persistent than those in inductive or resistive circuits, and indicated an average peak of about 300 volts per foot of arc length, for currents of about 100 amperes or more. Regarding system overvoltages arising from arcing grounds, the authors concluded the maximum to be approximately three times normal peak voltage from line to ground, and that it occurs on a sound phase and most frequently during the first cycle of the fault.

Minutes of Annual Meeting Held at Asheville June 22

The annual meeting of the American Institute of Electrical Engineers was held at the Grove Park Inn, Asheville, N. C., as the opening session of the annual summer convention, Monday morning, June 22, 1931. President W. S. Lee presided.

The annual report of the board of directors was presented in abstract by F. L. Hutchinson, national secretary. Printed copies were distributed to members in attendance and are available to any member upon application to Institute headquarters, New York. The report, which constitutes a résumé of the activities of the Institute during the fiscal year ending April 30, 1931, shows a total membership on that date of 18,334. In addition to the three national conventions and five District meetings, 1,628 meetings were held during the year by the local organizations of the Institute in the principal cities and educational institutions in the United States, Canada, and Mexico. The report will appear in full in the Quarterly Transactions of the Institute.

The report of the committee of tellers on the election of officers of the Institute was presented, and in accordance therewith President Lee declared the election of the following members, taking office August 1, 1931:

President:

C. E. Skinner (F'12), assistant director of engineering, Westinghouse Electric & Mfg. Company, East Pittsburgh, Pa.

Vice-Presidents:

W. B. Kouwenhoven (M'22), professor of electrical engineering, assistant dean of the Engineering School, Johns Hopkins University, Baltimore, Md.

W. E. Freeman (M'27), head, department of electrical engineering, assistant dean of College of Engineering, University of Kentucky, Lexington, Ky.

Paul H. Patton (M'25), telephone engineer, Northwestern Bell Telephone Company, Omaha, Neb.

A. W. Copley (F'26), engineering manager, Pacific Coast district, Westinghouse Electric & Mfg. Company, San Francisco, Calif.

L. B. Chubbuck (M'26), switching equipment engineer, Canadian Westinghouse Company, Ltd., Hamilton, Ont.

Directors:

L. W. Chubb (F'21), director of Westinghouse Research Laboratories, Westinghouse Electric & Mfg. Company, East Pittsburgh, Pa.

B. D. Hull (M'26), engineer, Southwestern Bell Telephone Company, Dallas, Tex.

H. R. Woodrow (F'23), electrical engineer, Brooklyn Edison Company, Inc., Brooklyn, N. Y.

National Treasurer:

W. I. Slichter (F'12 and national treasurer), professor of electrical engineering, Columbia University, New York, N. Y.

(These officers, together with the following hold-over officers, will constitute the board of directors for the next administrative year, beginning August 1: W. S. Lee (retiring president), Charlotte, N. C.; Harold B. Smith (F'13 and past-president), Princeton, Mass.; H. V. Carpenter (F'18 and vice-president), Pullman, Wash.; G. C. Shaad (F'13 and vice-president), Lawrence, Kans.; I. E. Moultrop (F'29 and vice-president), Boston, Mass.; H. P. Charlesworth (F'28 and vice-president), New York, N. Y.; T. N. Lacy (M'24 and vice-president), Detroit, Mich.; J. Allen Johnson (F'27), Buffalo, N. Y.; A. M. MacCutcheon (F'26), Cleveland, Ohio; A. E. Bettis (F'26), Kansas City, Mo. (terms expire July 31, 1932); J. E. Kearns, Chicago, Ill.; F. W. Peek, Jr., Pittsfield, Mass.; C. E. Stephens, New York, N. Y. (terms expire July 31, 1933); A. B. Cooper (M'16), Toronto, Ont.; A. E. Knowlton (F'30) and R. H. Tapscott (F'29), New York, N. Y. (terms expire July 31, 1934).

President Lee then congratulated President-elect Skinner (F'12) upon his

election and presented him with the president's badge. Mr. Skinner responded with a brief address, which was enthusiastically received.

The report of the committee on award of Institute prizes, as published in the June 1931 issue of ELECTRICAL ENGINEERING (p. 448) was read by A. E. Knowlton, chairman of the committee of award, after which the prizes were presented by President Lee.

The Lamme medal for 1930, which, as announced in the March 1931 issue of ELECTRICAL ENGINEERING (p. 230), had been awarded to W. J. Foster (F'16), of Schenectady, N. Y., was presented.

The annual presidential address was then delivered by President Lee, the subject being "Coordination—the Essence of Modern Engineering." (This address is published in full on p. 512 of this issue.)

Adjourned.

(Signed) F. L. HUTCHINSON,
National Secretary

"Who's Who in Engineering"

Engineers listed in the forthcoming edition of "Who's Who in Engineering" shortly will receive notification of the page upon which their listing occurs.

The publishers emphasize the fact that volumes of this compendium of engineering biographies will be available only to those placing reservations prior to publication, and urge prompt action on the part of any persons wishing to acquire the book.

Institute Policy Committee Appointed

At the May 19, 1931 meeting of the Institute's board of directors the question was raised—*should the Institute, with the object of enhancing the status of the engineering profession, devote more of its resources to non-technical activities, such, for example, as legislation, education, and the economic welfare of the engineer?*

The following resolution was adopted:

"RESOLVED: That the president be authorized to appoint a special committee on Institute policies for the purpose of studying the present and any proposed future activities of the Institute; this committee to invite and consider suggestions from any member, officer, or committee, and to make definite recommendations to this board regarding modifications of present activities and plans for any additional fields of work that the committee may deem desirable."

In accordance with this action, President Lee appointed the following committee:

Chairman, C. E. Stephens (M'22) (vice-president and northeastern district manager, Westinghouse Electric & Manufacturing Company, New York, N. Y.) director; present chairman of finance committee; member, committee on coordination of Institute activities, executive committee, U. S. National committee of the I. E. C., and the assembly of American Engineering Council.

Vice-Chairman, H. A. Kidder (F'20) (superintendent of motive power, Interborough Rapid Transit Company, New York, N. Y.) past-vice-president; present chairman, committee on engineering profession; member, board of examiners, law committee, assembly of American Engineering Council, and board of trustees of United Engineering Trustees, Inc.

H. P. Charlesworth (F'28) (vice-president Bell Telephone Laboratories, Inc., New York, N. Y.) vice-president New York City District; past-chairman, meetings and papers committee; chairman, committee on coordination of Institute activities; member, Edison medal, engineering profession, finance, Lamme medal, meetings and papers, and publication committees, and board of trustees of United Engineering Trustees, Inc.

F. L. Hutchinson (M'13) (national secretary, A. I. E. E.) member, committee on coordination of Institute activities, Edison medal, and publication committees, assembly of American Engineering Council, engineering societies library board.

J. A. Johnson (F'27) (chief electrical engineer Buffalo, Niagara & Eastern Power Corporation, Buffalo, N. Y.) director; present chairman, membership committee; member, Edison medal, executive, electrical machinery, and research committees.

E. S. Lee (F'30) (assistant engineer General Electric Laboratory, Schenectady, N. Y.) present chairman, Sections committee; member, committee on coordination of Institute activities, and instruments and measurements committee.

E. B. Meyer (F'27) (vice-president United Engineers & Constructors, Inc., Newark, N. J.) director; past-chairman, meetings and papers, and finance committees; present chairman, law committee; member, committee on coordination of Institute activities, Edison medal, finance, publication, and power generation committees.

W. S. Rodman (F'28) (professor of electrical engineering, University of Virginia) vice-president, Southern District; student Branch counselor; member, Sections and electrophysics committees, education research committee of Engineering Foundation, and assembly of American Engineering Council.

C. F. Scott (F'25 HM'29) (head of department of electrical engineering Yale University), past-president; chairman, development committee 1919; member, Lamme medal, standards and student Branches committees, assembly of American Engineering Council; past-member, many other Institute committees.

This committee held its first meeting June 8 at Institute headquarters and directed that through this notice in ELECTRICAL ENGINEERING the membership be invited and urged to submit through the national secretary any suggestions or criticisms relating to the present activities of the Institute; also regarding any additional activities which individual members may deem desirable.

Addresses Wanted

A list of members whose mail has been returned by the postal authorities is given below, with the address as it now appears on the Institute records. Any member knowing of corrections to these addresses will kindly communicate them at once to the office of the secretary at 33 West 39th St., New York, N. Y.

COLLINOT, MARCEL A., 88 Sherman Ave., Newark, N. J.
COLE, WILL G., Box 222, Westwood, Calif.
CORRIVEAU, F. M., General Electric Co., Schenectady, N. Y.
FALE, VICTOR E., 2422 Euclid Ave., Cleveland, Ohio.
FYLER, GEORGE W., Y. M. C. A., Schenectady, N. Y.
MCDONALD, I. M., 772 Pollokshaws Road, Glasgow, Scotland.
NUBER, FRANK J., 3831 Roseby St., Chicago, Ill.
O'SHEA, V., JR., 115 Broadway, New York, N. Y.
SULLIVAN, JOHN E., 6320 Kenmore Ave., Chicago, Ill.
TUNG, C. T., c/o Stone & Webster Engg. Corp., Hopewell, Va.

Personal

F. M. Feiker Appointed Commerce Director

The appointment of FREDERICK M. FEIKER (M'15) managing director of the Associated Business Papers, Inc., New York, N. Y., to the office of director of the Bureau of Foreign and Domestic Commerce was announced May 29, 1931, by President Hoover. Mr. Feiker succeeds W. L. Cooper who is withdrawing to resume his former duties as commercial attaché at London, England.

Born at Northampton, Mass., Mr. Feiker received his degree of B. S. in E. E. from Worcester Polytechnic Institute, Worcester, Mass., in 1904. He has served as editor of *Factory Magazine* and *Electrical World*; chairman of the editorial board of *System* and *Factory*; and vice-president of the McGraw-Hill Publishing Company, Inc., New York, N. Y. During 1920-21 he was Acting Assistant Secretary of Commerce and

served in the various capacities. Besides having been a member of the Institute for almost two decades, Mr. Feiker holds an active membership in the American Society of Mechanical Engineers and the Illuminating Engineering Society.

HAROLD B. SMITH (F'13) past-president of the Institute and for many years head of the department of electrical engineering Worcester Polytechnic Institute, Worcester, Mass., resigned his educational chair there effective June 1931. As one well known in engineering and education Dr. Smith always has carried forth a multiplicity of duties in these fields. His share in Institute activities has been abundantly represented by service on several of its committees simultaneously, including: law 1920-21; electrolysis and student branches 1920-27; instruments and measurements 1921-22; educational 1922-27; sections 1922-28; Edison Medal 1924-26, 1929-30, 1930-31; research, coordination of Institute activities, and meetings and papers 1924-27; code of principles for professional conduct 1928-29; executive 1929-31; and public policy 1930-31. He was appointed also to the John Fritz Medal board of award for 1929-33, the U. S. national committee of the I. E. C., the Chas. A. Coffin Fellowship & Research Fund committee 1929-30, and the American Engineering Council 1930-31. It is his hope to resume professional practise.

F. V. MAGALHAES (F'19) who left New York and his office as general superintendent of distribution and installation, New York Edison Company, to become vice-president of the Hall Electric Heating Company, Inc., now has been appointed general manager of his company in addition to his duties as vice-president. His professional career has been a busy one; during the past year he was vice-chairman of the Institute's committee on safety codes, an alternate representative for the Institute in the National Fire Protection Association (electrical department) and on the National Fire Waste Council; also a member of a special subcommittee of the standards committee dealing with reactive power. The year previous he served at various times as a member of the Institute's board of examiners and the meetings and papers committee; was member and chairman of the A. I. E. E. committee on instruments and measurements. For several years was one of the Institute's representatives to U. S. National committee of the International Electrotechnical Committee.

H. L. WILLS (A'20) inductive coordination expert as assistant to the vice-president and general manager of the Georgia Power Company, Atlanta, Ga., now has established a consulting engineering practise of his own, specializing in adjustment of relations between telephone, telegraph, railway signal, and automatic train control systems, including problems of electrolysis and radio interference. Mr. Wills was chairman of the Institute's Atlanta Section in 1921 and 1928, and has rendered much valuable service to the National Electric Light Association as a member of its inductive coordination committee (1923-27); chairman (1928-29). Mr. Wills has been active also in the association's joint operations with the Bell Telephone System (joint subcommittee on development and research, 1926-31) and with the American Railway Association's subcommittee on principles and practises (1929-31).

F. M. DENTON (F'28) head of the department and professor of electrical engineering, University of Mexico, Albuquerque, N. M. has been awarded fellowship in the City and Guilds of London Institute, the highest distinction that institute confers. Only eleven of its several thousand graduates since the inauguration of its Fellow in E. E. degree have received it; it was awarded to Mr. Denton as one "of a limited number of Associates (ACGI) with not less than five years of actual practise and having contributed to advancement of the industry." The City and Guilds College (School of the University of London) is said to be the foremost of engineering schools in the British Empire.

D. LEVINGER (M'30) engineer of manufacture, Western Electric Company, recently was elected one of its directors, the youngest member of the company's board. Already he has served the company for 21 years and now as its engineer of manufacture heads a large force of trained engineers and scientists. He is a member of the Institute of Mining and Metallurgical Engineers, and has served three years upon its research committee; he also is a member of the American Society of Mechanical Engineers, the American Society for Steel Treating, and the American Association for the Advancement of Science.

R. F. PACK (M'12) recently elected president of the Northern States Power Company has been identified with the electrical industry since 1891 when he engaged as office boy with the Toronto Electric Light Company. He was instrumental in the affiliation between the Canadian Electrical Association and the National Electric Light Association in the affairs of which he has always remained active. He worked with B. Gherardi (F'12 and past-president) vice-president of the A. T. & T., in improving harmonious relations between these two great industries.

T. H. CLEGG (M'21) who has been affiliated with the Philadelphia Rapid Transit Company as special engineer, on June 1, 1931, opened his own consulting offices at the same address, 1600 Walnut Street, Philadelphia, Pa. In the past, Mr. Clegg's work has been of a confidential nature appertaining to power investigations, and to the operation and management of power plants. For the past three years he has served the American Electric Railways Association on committees dealing with power contracts and mercury-arc rectifiers.

C. E. SKINNER (F'12) assistant director of engineering, Westinghouse Electric & Mfg. Company, East Pittsburgh, Pa., upon June 8, 1931, received the Lamme Medal annually awarded by Ohio State University to an alumnus "for meritorious achievement in engineering or the technical arts." Mr. Skinner has done much conspicuous professional work in many fields of electrical application. He has served the American Society of Testing Materials (1917-18), the Engineering Council (1917-19), and American Engineering Council (since 1923).

W. R. WHITNEY (A'01) vice-president and director of the research laboratory, General Electric Company, Schenectady, N. Y., was awarded the Franklin Medal of the Franklin Institute May 20, 1931. The award, which this year took place at Philadelphia, is made annually to "workers in physical science or technology without regard to country, whose efforts in the opinion of the administering committee on science and arts, have done most to advance a knowledge of physical science or its application."

JOSEPH O. PHELON (M'13) for 44 years identified with the Worcester Polytechnic Institute, Worcester, Mass., retired from the office of professor of electrical engineering June 1931. For several years after his graduation from that Institute, he taught in its physics department, but

in 1896 he was transferred to the newly formed department of electrical engineering where he has served as full professor since 1907 and as head of the department in 1911-13. He now plans to make California his place of residence.

W. S. GIFFORD (A'16) president, American Telephone & Telegraph Company, New York, N. Y. has been elected a member of the board of trustees of Cooper Union, New York City, to succeed Thomas Snell, deceased. This continues a tradition of service to Cooper Union by men in the forefront of industry and public affairs.

W. F. FENNINGER (M'22) who has been serving as supervisor of electric courses at the Rochester (N. Y.) Mechanics Institute, is now state supervisor of technical and cooperative education, with headquarters at Albany. In this capacity he visits the several high schools in which technical courses are given offering suggestions to bring them up to State standards or for maintaining these standards if already achieved.

M. K. MCGRATH (M'27) who has been serving as vice-president of the International Telephone & Telegraph Corporation, Aldwych, London, W. C. 2, England, left there June 6, 1931, to take up residence in America. His address for the present will be in care of the International Telephone & Telegraph Corporation, New York, N. Y.

L. C. ARMITAGE (A'28) who has been industrial heating engineer for the General Electric Company, Schenectady, N. Y. has now become designing engineer for the Ajax Electric Company, Inc., at Philadelphia, Pa. where his principal work will be the design and development of a variable temperature electric decorating kiln.

R. D. BEAN (A'21) formerly manager of the engineering development department of The Brown Instrument Company, Philadelphia, has been made chief engineer of that company. Mr. Bean's extensive field investigations cover many applications of measuring instruments.

F. J. AIREY (A'19) division manager of the General Electric Supply Corporation at Los Angeles, Calif., has been elected chairman of the National Electric Wholesalers' Association. He has been 42 years in the business of electrical merchandising.

B. L. ROBERTSON (A'26) assistant professor of electrical engineering, Pennsylvania State College, State College, Pa., has left the East to enter the department of electrical engineering of the University of California at Berkeley, Calif.

H. C. WOLFE (A'28) recently has become associated with the Empire Industries, Inc., Cleveland, Ohio, as its president. His work with the company will be the development of industrial application of chromium plate for engine parts, turbine blades, molds, and various tools and dies.

R. D. MCCARTER (M'09) who has been doing a consulting engineering business in New York City, has joined the European Gas & Electric Company, Aldwych, London, W. C. 2, England.

Obituary

H. EUGENE CHUBBUCK (F'13) retired operating head of the Illinois Traction System, Inc., whose name is closely linked with the story of electricity and its application, died June 4, 1931 in Peoria, Illinois, after an extended illness. He was born in Utica, New York, and educated in the public schools of that city supplemented by one year at Whitestown Seminary and later a special course in chemistry and physics. In 1880 he returned to Whitestown as instructor in these subjects. He devoted the years 1881-1883 to shop practise in telegraph and philosophical instruments, the last year for the greater part being spent on electric lighting and testing machinery. In 1883 he engaged with the Thomson Houston Company as an expert and installed the first lighting plant at Pawtucket, R. I. The Narragansett Electric Company of Providence, R. I. next appointed him as its electrical engineer, a service occupying him for one year, and terminating in his return to special expert and construction work for Thomson Houston. In 1898 he joined the General Electric Company for special work and was given charge of its sales offices at Salt Lake City. He was the son of A. S. Chubbuck and grandson of S. W. Chubbuck, both well known to the profession for establishing the manufacture of telegraph machinery, and the building of some of the first instruments used. Mr. Chubbuck joined the Institute as an Associate four years after its organization, when the grade of Associate was the compulsory initial grade.

T. H. U. ALDRIDGE (F'18) vice-president and general manager of the Shanghai Power Company, Shanghai, China, died suddenly on the 10th of May, 1931. A native of London, England (1874), his residence in China dates back to 1901 when he accepted appointment as municipal electrical engineer to the International Municipal Council of Shanghai. By the end of 1916 his staff had increased from three Europeans and 120 Chinese to 76 Europeans and 1,099 Chinese. As engineer-in-chief and manager of the municipal electricity department Mr. Aldridge was directly responsible to the electricity committee for both technical and commercial direction of undertaking as well as matters involving finance. He was responsible also for the general design and layout of two large power stations including all essentials of a central station light, heat, and power system. During his régime the system was converted from single-phase, 100-cycle, 2,000-volt generation and distribution to a modern 50-cycle system. The annual report of the Shanghai Municipal Council's electricity department (1917) attests the success of his undertakings.

CARLYLE KITTREDGE (F'22) assistant to the vice-president of the Michigan Bell Telephone Company, Detroit, Mich., and for many years its chief engineer, died in the Harper Hospital that city May 23, 1931, the result of an operation for acute appendicitis. He was born at Mason, Mich., July 19, 1874. As past-chairman of the Institute's Detroit-Ann Arbor Section (1921) he has been specially active for its interests. He also was a member of the Detroit Engineering Society. In 1897 he was graduated from the University of Michigan with the degree of B. S. in E. E., and two years later joined the Electric Light & Power Company, Van Wert, Ohio, as its superintendent. In 1900 he engaged with the Central Union Telephone Company, doing special inspection work in Ohio, Indiana, and Illinois, ultimately becoming assistant chief engineer. On August 15, 1911, he joined the Michigan State Telephone Company as plant engineer, a position which he held until 1920 when he became chief engineer. At the time of his death he was secretary of the Wolverine section of the Telephone Pioneers of America.

JAY L. STANNARD (M'29) chief engineer of the department of public utilities, City of Tacoma, Washington, died March 13, 1931 having been ill less than a month. He was a native of Chittenango, N. Y. (1866); after two years in common and high school at Shell Rock, Iowa, he spent two years at Cornell

College, Mount Vernon, Iowa. Until 1887 his time was occupied chiefly with a civil engineering practise. For the next ten years he acted as engineer for the contractor on several of the power and lighting projects of the Pacific Coast. Prior to his arrival in Tacoma (1923) Mr. Stannard had been identified with many irrigation, water works, and power plant developments along the Pacific Coast; the Grant Smith Company project in California, the Cedar River plant at Seattle, and the Bull Run plant at Portland. From 1912 to 1919 he was consulting engineer for the North Coast Power Company in Portland. At the time of his death he was serving his second term as president of the Tacoma Section of the American Society of Civil Engineers, which he had been instrumental in establishing.

WILLIAM F. CALLAHAN (A'23) engineering assistant, Western Union Telegraph Company, New York, N. Y., died May 31, 1931, at the age of forty. After the completion of studies in machine design, manual training and applied electricity at Pratt Institute, his first business connection (1910) was when he joined the Western Electric Company, New York, with which he remained as machine hand and inspector until 1913; then he became draftsman of Bramhall Deane & Company, Brooklyn, N. Y. In March 1914 he engaged with the Western Union Telegraph Company, New York City, spending three years as draftsman, followed almost immediately by appointment as engineering assistant, the position he held until his death. Mr. Callahan belonged to the Institute's New York Section, in which he was active.

Mr. Alexander, winner of first prize, recently has won a Tau Beta Pi scholarship for $750 and a $500 tuition scholarship from the Massachusetts Institute of Technology. In his freshman year he received a $1,000 prize offered for the best paper by the American Chemical Society.

The following names of officers of the Oklahoma City Section for next year were announced: C. T. Almquist (A'28) associate professor of electrical engineering, University of Oklahoma, chairman; A. Naeter (M'30) head electrical engineering department, Oklahoma A. & M. College, vice-chairman; and C. E. Bathe (A'29), superintendent of radio and standards, Oklahoma Gas & Electric Co., secretary-treasurer.

Local Meetings

Utah Section and Branch Meet

The Utah Section and the University of Utah Branch held their annual joint meeting for the presentation of a student program on May 18. This was the last meeting of the Section for the present administrative year.

The following papers were presented by students:

KEYING OF CONTINUOUS-WAVE TRANSMITTERS, by M. R. Johnson and L. K. Irvine.

ILLUMINATION OF THE UNIVERSITY CAMPUS, by L. D. Schroder and J. O. Carlston.

STROBOSCOPIC EFFECTS WITH NEON GLOW TUBES, by Courtney Campbell.

INVESTIGATION OF THE ACOUSTICS OF KINGSBURY HALL, by Fred Lundberg and F. M. Neal.

CHOICE OF PETROLEUM PUMP STATION EQUIPMENT, by V. J. Sittel, Oklahoma A & M College.

FACTORS DETERMINING THE RATING OF UNDERGROUND CABLES, by Wm. M. Achgill, A. B. Bartow, T. A. Bloss, University of Oklahoma (presented by Wm. M. Achgill).

GROUNDS AND METHODS OF TESTING THEM, by Hubert I. Short, Oklahoma A. & M. College.

SYSTEM SOLUTION BY THE METHOD OF SYMMETRICAL COMPONENTS, by R. J. Thompson, University of Oklahoma.

THYRATRON TUBE AND ITS RECENT APPLICATIONS, by W. E. Nichols, Oklahoma A. & M. College.

RADIO FIELD INTENSITY SURVEY, by G. S. Hammonds, University of Oklahoma.

TRANSMISSION LINES: GENERATOR-END REQUIREMENTS VERSUS LOAD CONSTANTS, by P. H. Foster, Oklahoma A. & M. College.

APPLICATION OF KIRCHOFF'S LAWS AND SUPERPOSITION OF CURRENTS IN CALCULATING LOOP AND NETWORK CIRCUITS, by S. Alexander, University of Oklahoma.

Oklahoma City Section Meets with Branches

The annual joint meeting of the Oklahoma City Section and the student Branches at the University of Oklahoma and the Oklahoma A. & M. College was held at the latter school on May 18, 1931. During the morning program students of the two schools presented the following technical papers:

The program was followed by a luncheon (attended by about 115) and the inspection of engineering laboratories.

At an afternoon session authors of three papers were awarded prizes as follows:

First prize ($15) S. Alexander, University of Oklahoma

Second prize ($10) Waldo E. Nichols, Oklahoma A. & M. College

Third prize ($5) Hubert I. Short, Oklahoma A. & M. College

Section and Branch Join in Meeting at Cincinnati

The annual joint meeting of the Cincinnati Section and the University of Cincinnati Branch was held at the university on May 14, with an attendance of 80; the preceding dinner was attended by 38.

The following program was presented by seniors in electrical engineering:

CHOKE-COIL DESIGN, by D. T. Michael.

STUDY OF A SPOT WELDER, by F. F. Osterholz.

STUDY OF A 500-CYCLE GENERATOR, by G. H. Pettibone.

EXPERIMENTAL STUDY OF MEANS OF LESSENING STATIC IN RECEIVING SETS, by G. F. Platts.

SPEED CONTROL OF A D-C. MOTOR, by R. M. Seltz.

PITTING IN TELEPHONE RELAY CONTACTS, by Henry Suter.

Baltimore Section Awards Prizes

Each alternate year the Baltimore Section has a prize paper meeting. For the contest this year six papers were submitted for three of which the following prizes were awarded at this meeting:

First prize: ($25)—W. P. Taylor, Consolidated Gas Electric Light and Power Company. LOCATING POWER CABLE FAULTS BY MEANS OF A CONSTANT CURRENT TRANSFORMER WITH SHORT CIRCUITING SWITCH.

Second prize: ($15)—L. J. Berberich, graduate student, Johns Hopkins University. A METHOD FOR MEASURING THE PHASE ANGLES OF SHIELDED RESISTORS.

Third prize: ($10)—G. M. L. Sommerman, graduate student, Johns Hopkins University. THE SPARK DISCHARGE IN AIR.

The speakers were invited to an executive dinner preceding the regular meeting. The following officers were elected for the year 1931-32; chairman K. A. Hawley (M'12) chief engineer Locke Insulator Corporation; vice-chairman L. G. Smith (M'25) assistant to general superintendent, Consolidated Gas Electric Light & Power Corporation; secretary-treasurer J. Wells (A'27) development manager Western Electric Company.

Faraday Discoveries Celebrated at Lehigh University

In honor of the centennial of Faraday's discovery of electromagnetic induction, engineering students at Lehigh University, Bethlehem, Pa., under the leadership of the local student Branch of the Institute, held a special joint meeting April 29, 1931. Members of the several engineering societies at Lehigh presented papers descriptive of different phases of Faraday's scientific work and staged apparatus demonstrations designed to commemorate Faraday's more important discoveries.

Eight students cooperated in the preparation and presentation of five papers as follows:

1. Faraday the Man, by F. W. Matchett, M. E. '31.

2. Contribution to Chemistry, by R. C. Smith, Chem. '31 and L. S. Millelot, Chem. '31.

3. Contribution to Metallurgy, by W. H. Wagner, Met. E '31 and J. S. Harrison, Met. E. '31.

4. Electromagnetic Induction, by R. E. Snyder, E. E. '31 and L. R. Wanner, E. E. '31.

5. Optics, by D. L. MacAdam, Engg. Physics '32.

Past Section Meetings

Akron

Some Engineering Features in Connection with Heavy Construction, by W. S. Lee, president, A. I. E. E. Illustrated by several reels of motion pictures. Dinner meeting. Election of officers for 1931-32: R. R. Krammes, chairman; R. A. Hudson, secretary; P. C. Smith, treasurer. May 22. Attendance 50.

Boston

Annual meeting and election of following officers: C. A. Corney, chairman; F. D. Hallock, vice-chairman; G. J. Crowdes, secretary-treasurer. Motion pictures and other entertainment remainder of the evening. May 14. Attendance 121.

Cincinnati

W. Weftendorp, General Electric Company, spoke on the study of the light penetration and its detection through fog. A representative of the Army Air Corps of Dayton outlined Army preparedness plans with particular reference to obtaining materials and construction for airplanes. Dinner preceded the meeting. May 5. Attendance 250.

Annual golf tournament and dinner preceded the evening meeting at which Prof. F. H. Bird, University of Cincinnati, spoke on Economic Phases of City Development. Election of officers: E. S Fields, chairman; J. A. Noertker, secretary-treasurer. June 4. Attendance 46.

Connecticut

Annual outing and dinner dance. May 23. Attendance 115.

Dallas

Lead Storage Batteries and the Fundamental Principles of Battery Operation and Maintenance, by W. E. Dunn, Electric Storage Battery Company. Election of officers: Gibbs A. Dyer, chairman; S. M. Sharp, secretary-treasurer. May 25. Attendance 104.

Denver

Business meeting. May 12. Attendance 17.

Detroit-Ann Arbor

The Electrical Industry and Electrical Engineering in Soviet Russia, by A. Dovjikov, Westinghouse Elec. & Mfg. Company. Prior to this talk many members inspected the Moore's Park station of the City of Lansing. May 19. Attendance 200.

Erie

Vacuum Tubes, by A. W. Hull, General Electric Company. Election of officers: P. R. Urich, chairman; C. V. Roberts, secretary. May 19. Attendance 83.

Houston

Storage Batteries, by W. E. Dunn, Electric Storage Battery Company. J. S. Waters elected secretary. May 26. Attendance 15.

Indianapolis-Lafayette

Vacuum-Tube Control, by S. D. Fendley, General Electric Company. May 15. Attendance 94.

Iowa

Railroad Electrification Developments in America and Abroad, by F. W. Peters, General Electric Company. Joint meeting with the Des Moines Engineers Club and the Des Moines Architects Club. Election of officers: H. B. Hoffhaus, chairman; E. W. Schilling, secretary-treasurer. May 14. Attendance 90.

Ithaca

Election of officers: W. E. Meserve, chairman; B. K. Northrop, secretary-treasurer. Dinner meeting. May 29. Attendance 13.

Lehigh Valley

Annual meeting and exhibition at which applications of the photoelectric cell, metering equipment, and other recent electrical developments were displayed by various manufacturers. Preceding dinner the following motion pictures were shown: "Dynamic America," "The Romance of Power," "Deion Oil Circuit Breakers." Reports from the chairmen of the local committees were read and officers for the year 1931-32 were announced. Planning to Avoid Depressions, by E. C. Stone, vice-president A. I. E. E. District No. 2, was presented by R. L. Kirk, Duquesne Light Company. May 16. Attendance 135.

Los Angeles

Two papers concerning the R. C. A. 50-kw. broadcasting transmitter being installed for KFI, were presented by J. J. Farrell and G. W. Fyler, both of the General Electric Company. Election of officers as follows: P. S. Biegler, chairman; F. E. Dellinger, secretary. Joint meeting with the Institute of Radio Engineers. May 19. Attendance 203.

Louisville

Annual meeting. Reports of local committees were read, and election of officers was made as follows: Philip P. Ash, chairman; C. M. Ewing, secretary-treasurer. Dinner and entertainment followed. June 4. Attendance 37.

Memphis

Power Plant Generation and Utilization, by Robert Bruce, Memphis Power and Light Company;

The New 110-Kv. River Crossing, by M. Eldredge, Memphis Power & Light Company, and chairman, Memphis Section. May 12. Attendance 42.

Fuseless Home, by H. G. Nichols, Westinghouse Elec. & Mfg. Company. June 9. Attendance 36.

Milwaukee

Inspection trip through the Globe-Union Mfg. Company plant, and talk by W. R. Vicarey of that company on

"Sparks from a Lifetime with Batteries." May 6. Attendance 280.

AIR LAW, by Professor Carl Zollman, Marquette University Law School. Election of officers: Carl H. Kreuger, chairman; E. U. Lassen, secretary. Dinner meeting. June 3. Attendance 32.

Niagara Frontier

SAFETY, by W. S. Sterne, president, Safety Club. This talk was concluded by a motion picture film on Lux fire extinguishing equipment especially applied to oil fires;

SOME PHASES OF INDUSTRIAL ECONOMICS, by Dexter S. Kimball, dean, College of Engineering, Cornell University. Informal dinner preceded the meeting. May 15. Attendance 60.

Philadelphia

LIGHTNING ARRESTERS AND THEIR APPLICATION, by E. Beck, Westinghouse Elec. & Mfg. Company. May 11. Attendance 175.

Pittsburgh

THE CHARACTERISTICS AND APPLICATIONS OF GRID-GLOW TUBES WITH DEMONSTRATIONS, by D. D. Knowles and S. P. Sashoff, both of Westinghouse Elec. & Mfg. Company. Demonstration of grid-glow tubes. Buffet luncheon served after the meeting. Joint meeting with the Engineers' Society of Western Pennsylvania. Election of officers: F. A. Connor, chairman; Thomas Spooner, secretary-treasurer. May 12. Attendance 276.

Rochester

RADIO INTERFERENCES, by H. J. Klumb, Rochester Gas & Electric Company. Joint meeting with the Institute of Radio Engineers. Election of officers: Frederic C. Young, chairman; C. F. Estwick, vice-chairman; E. K. Huntington, secretary-treasurer. May 29. Attendance 36.

San Francisco

THE ELECTRIC PROPULSION OF SHIPS, by Captain C. S. McDowell, U. S. Navy. Election of officers for year 1931-32: E. A. Crellin, chairman; E. F. Maryatt, vice-chairman; W. C. Smith, secretary. This meeting was held on board the *U. S. S. Pennsylvania*, and those present inspected the ship at the conclusion of Captain McDowell's address. May 15. Attendance 300.

Seattle

Papers presented by Section members were as follows:

ANALYSIS OF DISTRIBUTION SUBSTATION COSTS, by A. Shipek;

INDUSTRIAL ELECTRONIC TUBES, by L. B. Robinson;

ELECTRIC LIGHT—KING AND SERVANT SUPREME, by George Boyd;

GENERAL-PURPOSE SYNCHRONOUS MOTORS AND CONTROL, by R. B. Lane. A prize of $25.00 for presentation of the best paper was awarded A. Shipek. Election of officers: M. T. Crawford, chairman; A. F. Darland, vice-chairman; C. B. Carpenter, secretary-treasurer. May 19. Attendance 52.

Sharon

OXYGEN—THE WONDER WORKER, by G. E. Harke, Air Reduction Sales Company. Illustrated by moving pictures and demonstrations of liquid oxygen. Election of officers: R. M. Field, chairman; A. M. Wiggins, secretary-treasurer. June 2. Attendance 130.

Toledo

RADIO SUPERVISION, by J. E. Brown, U. S. Department of Commerce. The lecture was followed by an inspection trip to the Toledo Police, Radio, and Fire Alarm Building. May 22. Attendance 150.

Washington

SOME NOTES ON ENGINEERING IN ELECTRIC UTILITY OPERATION, by J. J. Ferry, Potomac Electric Power Company. Election of officers: G. L. Weller, chairman; T. J. MacKavanagh, vice-chairman; C. M. Brown, secretary-treasurer. May 12. Attendance 88.

Past Branch Meetings

University of Arizona

BENJAMIN GARVER LAMME, by H. P. McGovern, student. May 15. Attendance 5.

TELEVISION, by T. Phillips, student. Election of officers: P. F. Hawley, chairman; F. Phillips, vice-chairman; T. S. Henderson, secretary-treasurer. May 22. Attendance 6.

University of Arkansas

CATHODE-RAY OSCILLOGRAPH, by A. Bost, student;

STUDIES IN LIGHTNING PROTECTION, by Prof. W. B. Stelzner, counselor. Election of officers: Harold D. Albrecht, chairman; H. G. Thomasson, vice-chairman; Robert Vining, secretary; Paul Johnson, treasurer. May 13. Attendance 16.

Armour Institute of Technology

METHODS OF TESTING RADIO RECEIVERS, by R. K. Pew, United Air Cleaner Corporation. May 15. Attendance 37.

Election of officers: W. L. Jost, chairman; T. A. McGill, vice-chairman; R. H. Frye, secretary, G. L. Bonvallet, treasurer. May 29. Attendance 65.

Brooklyn Polytechnic Institute

ENGINEERING EDUCATION SUBSEQUENT TO GRADUATION, by John C. Parker, vice-president, Brooklyn Edison Company. May 7. Attendance 40.

ELECTRO-ANESTHESIA, by A. E. Cross, student;

TURBINE POWER IN SHIPS, by R. Buehl, student. Two films shown,—"Big Deeds" and "Hydroelectric Power." May 15. Attendance 20.

Bucknell University

Discussion of methods of increasing Branch activities. Farewell meeting to the senior members; luncheon was served thereafter. May 20. Attendance 9.

California Institute of Technology

SOME EDISON COMPANY DEVELOPMENTS, by R. J. C. Wood, Southern California Edison Company, Ltd. Election of officers: Patrick B. Lyons, chairman; Paul F. Arnerich, vice-chairman; Robert W. St. Clair, secretary-treasurer. May 21. Attendance 45.

Case School of Applied Science

Election of officers: W. J. Lattin, president; W. J. Cherney, vice-president; K. R. Spangenberg, secretary; M. W. Ferguson, treasurer. April 30. Attendance 89.

Clarkson College of Technology

Election of officers: Charles O. McNairn, chairman; Joseph H. O'Rourke, secretary; William E. Lehner, treasurer. April 23. Attendance 59.

Inspection trip to the Massena plant of Aluminum Company of America. April 27. Attendance 15.

Clemson Agricultural College

Election of officers: H. S. Montgomery, chairman; H. C. Woodson, vice-chairman; C. A. Farish, secretary. May 14. Attendance 32.

Colorado State Agricultural College

Film—"Wizardry of Wireless." Election of officers: Leroy Sweet, president; Alfred Holdon, vice-president. May 11. Attendance 10.

University of Denver

Business meeting. May 7. Attendance 15.

LIFE OF FARADAY, by L. C. Grussler;

PRE-FARADAY DEVELOPMENTS, by I. Olcovich;

TYPICAL FARADAY EXPERIMENTS, by A. Gessell;

LATER DEVELOPMENTS, by E. R. Gaerttner. After these talks the laboratories were open for inspection. May 22. Attendance 60.

Election of officers: L. C. Grussler; E. R. Gaerttner, vice-president; Irwin Olcovich, secretary-treasurer. May 26. Attendance 15.

Film—"Turbine with Solid Rotor." June 2. Attendance 16.

University of Detroit

Fourth annual banquet held at the Cadillac Athletic Club. Election of officers: Bernard Sharkey, chairman; P. Zoufal, vice-chairman; John Schenk, secretary; Thomas M. Ward, treasurer. June 3. Attendance 60.

University of Florida

MEASUREMENT OF GROUND RESISTANCES, by A. W. Harris, student. May 13. Attendance 25.

Harvard University

THE QUEENSTON-CHIPPAWA POWER-DEVELOPMENT, by R. Bullwinkle, student;

PUBLIC UTILITIES, by Eric A. Walker, student;

THE A. I. E. E. NORTH EASTERN DISTRICT MEETING AT ROCHESTER, by J. H. Wright, student. Election of officers: Eric A. Walker, chairman; Robert D. Hickok, Jr., vice-chairman; Charles N. Mason, secretary-treasurer. May 19. Attendance 14.

Inspection trip to the toll exchange of the New England Telephone and Telegraph Company, Boston. May 21. Attendance 10.

Iowa State College

Election of officers: W. L. Huebner, president; W. Hardman, vice-president; G. Franks, secretary; M. Cain, treasurer. May 22. Attendance 21.

Kansas State College

Election of officers: G. E. Cain, president; D. E. West, secretary. May 14. Attendance 100.

Lehigh University

THE HISTORY OF THE ELECTRICAL INDUSTRY, by J. M. Bisbee, student;

DEVELOPMENTS IN THE ELECTRICAL FIELD IN 1930, by J. F. Miller, student;

SOLUTION OF LIGHTNING PROBLEMS, by J. B. Sponsler, student. Election of officers: L. F. Underwood, president; J. D. Brown, vice-president; J. J. Grinevich, treasurer; C. W. Banks, secretary. May 13. Attendance 40.

Lewis Institute

Business meeting. Prof. F. A. Rogers nominated for counselor. May 1. Attendance 15.

Inspection trip to the plant department of the American Tel. & Tel. Company. June 3. Attendance 17.

HOW I GOT INTO ENGINEERING, by A. B. Smith, Automatic Electric Company. June 5. Attendance 68.

Michigan State College

Illustrated talk given by F. Harbin, student, featuring a film entitled "Radio Communication on Trains." May 12. Attendance 23.

Several talks by students and a demonstration of the "Telemat." Joint meeting with the University of Michigan Branch. May 28. Attendance 32.

TO FIND THE MAXIMUM SPAN OF A CATENARY IF THE DENSITY, TENSILE STRENGTH, AND GRAVITY REMAIN CONSTANT, by L. Switzgable, student;

DISCUSSION OF THE EFFECT OF DIVISION OF LOAD UPON ROTARY CONVERTER SYSTEMS, by G. T. Hittle, student. Explanation of the recording interferometer given by Prof. C. W. Chamberlain. June 9. Attendance 29.

University of Michigan

Business discussion. May 13. Attendance 16.

Annual banquet at which the following program was presented:

JOSEPH HENRY, by L. C. Poole, student;

A RUSSIAN MEETS A TURK, by P. D. Kalachov, student;

MICHAEL FARADAY, by L. Zanoff, student;

THE HAND IS QUICKER THAN THE EYE, by Prof. A. D. Moore;

BEFORE THE DROUGHT, by Dean Emeritus M. E. Cooley. May 26. Attendance 60.

School of Engineering of Milwaukee

LIFE OF STEINMETZ, by J. D. Ball, vice-president of the school. May 13.

University of Minnesota

Tenth biennial electrical engineers' party. April 17-18. Attendance 4,100.

Banquet meeting. Election of officers: Martin G. Swanson, chairman; Harold L. Ericson, vice-chairman; Scott McDermott, secretary-treasurer. May 19. Attendance 33.

Mississippi A. & M. College

Election of officers: J. M. Caldwell, chairman; C. R. Lillybridge, vice-chairman. May 20. Attendance 27.

University of Missouri

THE POSSIBILITIES IN ENGINEERING, by R. V. Wright, president of A. S. M. E. Joint meeting with the A. S. M. E., A. S. C. E., and A. I. Ch. E. April 30. Attendance 43.

AUDIBLE LIGHT, by J. B. Taylor, General Electric Company. May 18. Attendance 176.

Montana State College

TRANSFORMER DESIGN, by R. Bjork, student;

VOLTA POWER PLANT, by N. Hovey, student;

BLACK EAGLE PLANT, by T. Micka, student. May 14. Attendance 99.

THE ELECTRICAL SHOW AT WASHINGTON STATE COLLEGE, by W. Rightmire, student;

THE IMPEDANCE BRIDGE, by P. O. Koetitz, student;

OFFICE ILLUMINATION, by R. Rydell, student. May 21. Attendance 94.

University of Nebraska

The Lincoln Telephone & Telegraph Company's first aid team gave a demonstration covering the high points of first aid work. May 13. Attendance 45.

University of Nevada

Election of officers as follows: Donald Knapp, chairman; Calvin Dodson, vice-chairman; Orvis Reil, secretary-treasurer. May 3. Attendance 21.

University of New Hampshire

Moving pictures and talks by E. J. Shaw and L. M. Shampeau, both of the Westinghouse Elec. & Mfg. Company. May 6. Attendance 56.

Talk by W. S. Keay, New England Gas & Electric Association. May 20. Attendance 80.

Business meeting. May 27. Attendance 16.

University of New Mexico

Smoker. ECONOMICS OF NEON LIGHTING, by E. Huffman and H. Mendenhall, students. H. Bangerter and S. Pelatowski, students, gave a demonstration of some of the effects of ultra-short radio waves. May 28. Attendance 21.

College of the City of New York

TRANSMISSION OF POWER, AND HIGH-VOLTAGE INSULATORS, by Mr. Wildebrandt, Ohio Insulator Company. May 21. Attendance 15.

University of North Carolina

ENGINEERING IN THE LATIN COUNTRIES, by Professor Bennett. May 14. Attendance 23.

North Dakota State College

RADIO BROADCASTING, by D. F. Holaday, student;

MAGNETISM, by B. Weiss, student;

MICHAEL FARADAY, by E. Blomquist, student;

SOME ACTUAL EXPERIENCES, by R. Stockstad, student;

LIFE AFTER GRADUATION, by Professor H. Rush, counselor;

RELATIONS OF INDUSTRY TO COLLEGE MEN, by J. D. Taylor, Northwestern

Bell Telephone Co. May 27. Attendance 15.

University of North Dakota

PHOTOELECTRIC CELLS AND APPLICATIONS, by Eugene Becken, student;

THE INSTITUTE AND ITS FUNCTIONS, by Prof. H. F. Rice, counselor. May 13. Attendance 28.

University of Notre Dame

Annual picnic. May 16. Attendance 160.

THE MARVELS OF SOUND TRANSMISSION, by S. P. Grace, assistant vice-president, Bell Telephone Laboratories, Inc. May 19. Attendance 1,300.

Ohio Northern University

Banquet meeting. ELECTRICAL ENGINEERS IN INDUSTRY, by Prof. A. D. Moore. Election of officers: O. R. Jacobs, president; B. Wyant, vice-president; W. Gideon, secretary; O. Hawes, treasurer. May 29. Attendance 75.

Ohio State University

Demonstrations were performed by the students using the new equipment just acquired for the electrical engineering department. May 1. Attendance 60.

Ohio University

THE LARGE DIFFERENCES WHICH ARE MADE BY THE LITTLE DIFFERENCES IN MEN, by Dr. E. B. Bryan, president of the University. Election of officers: George Wyckoff, chairman; William Miller, vice-chairman; William Cooper, secretary-treasurer. May 6. Attendance 41.

Oregon State College

SUBMARINE CABLES, by E. D. Pearson, North Western Electric Company. S. B. Clark, of the same company, supplemented this talk by describing the manufacture of submarine cables. Election of officers: Dale Hansen, president; Elliott MacCracken, vice-president; George Howie, secretary; Stewart Kibbe, treasurer. May 12. Attendance 71.

Pennsylvania State College

REPORT OF OSCILLOGRAPHIC STUDIES OF THE SOURCES OF COMMUTATOR RIPPLES IN D-C. MACHINERY WITH PARTICULAR REFERENCE TO THE ROTARY CONVERTERS, by Messrs. Conrad, Forster, Foster, and Pollock, students;

REPORT OF CAPACITOR INDUCTION MOTOR STUDIES, by Messrs. Henderson, Kennedy, Lauth, and Sauter; students;

DEMONSTRATION OF THE STROBOSCOPIC POSSIBILITIES OF THE NEON LAMP, by W. W. Harris, student.

Illustrated lecture on ALASKAN SALMON FISHERIES, by Prof. B. L. Robertson. May 18. Attendance 40.

Purdue University

Two films shown—"Voices Across the Sea" and "By-Products of a Telephone Research Laboratory." Election of officers: P. O. Peterson, president; M. W. Brown, vice-president; E. M. Sharer, secretary; G. K. Miller, treasurer. May 15. Attendance 30.

Rhode Island State College

Business meeting. May 27. Attendance 6.

Rice Institute

Election of officers: M. E. Kattmann, chairman; H. A. Martin, vice-chairman; E. A. Turner, Jr., secretary; R. C. Bearmann, treasurer. May 13. Attendance 20.

University of South Carolina

ALEXANDER GRAHAM BELL, by W. O. Farnam, student;

SOUND WITH PICTURES, by R. L. Phillips, student;

SILVER SELENIDE WITH A SECRET METAL USED BY A GERMAN TO GET ELECTRICITY FROM SOLAR RAYS, by J. T. Sanders, student;

THE X-RAY—NEW WATCH-DOG OF SAFETY, by J. B. Dent, student. May 18. Attendance 31.

Annual banquet. May 16. Attendance 16.

THOMAS ALVA EDISON, by W. E. Crum, student;

THE VARIABLE MU TETRODE, by J. W. Palmer, student;

A SOUTH CAROLINIAN—W. S. LEE, by C. D. Caughman, student. May 11. Attendance 29.

University of Southern California

RECENT DEVELOPMENTS IN THE ELECTRICAL INDUSTRY, by W. F. Grimes, Westinghouse Elec. & Mfg. Company. April 22. Attendance 23.

CHAIN BROADCASTING, by Paul Johnson, Pacific Tel. & Tel. Co. April 29. Attendance 26.

APPLICATION OF ELECTRICITY IN THE OIL FIELDS, by C. J. Ruzicka, Standard Oil Company. May 6. Attendance 26.

LAYOUT OF SUBSTATIONS ON THE 220-KV. DISTRIBUTION SYSTEM OF THE EDISON COMPANY, by J. M. Gaylord, Southern California Edison Company, Ltd. May 13. Attendance 26.

H. M. Cox, Bureau of Power & Light, gave instructions on artificial respiration and some useful hints on first aid, with special reference to burns which might be received by an electric current. Election of officers: M. C. Marshall, chairman; John Ganzenhuber, vice-chairman; Louis Bayha, secretary; Oliver Jessen, treasurer. May 20. Attendance 28.

DEVELOPMENT OF THE U. S. MOTORS CORPORATION, by W. M. Hogne, of that company. May 27. Attendance 31.

Stanford University

LIFE AND WORK OF MICHAEL FARADAY, by G. W. Dunlap, student;

EXPERIENCES AT THE GENERAL ELECTRIC TEST COURSE. by M. Born, student. May 19. Attendance 12.

RESIDUAL CURRENTS AND VOLTAGES IN ELECTRICAL POWER SYSTEMS, by G. H. Kimball and C. A. Bairos, students. June 2. Attendance 10.

Election of officers: Madison R. Jones, Jr., chairman; G. W. Dunlap, vice-chairman; Ronald H. Born, secretary-treasurer. June 5.

University of Tennessee

MERCURY VAPOR LAMPS, by H. DuBose, student. Election of officers: H. M. Patterson, chairman; G. L. Dyer, vice-chairman; C. T. Nunley, secretary-treasurer. May 5. Attendance 13.

University of Texas

RESEARCH AND INDUSTRY, by E. L. Manning, General Electric Company. Joint meeting with the A. S. M. E. and A. S. C. E. April 22. Attendance 60.

THEORY AND APPLICATIONS OF ELECTRIC RELAYS, by H. P. Robinson, Houston Power & Light Company. May 15. Attendance 23.

Virginia Polytechnic Institute

Election of officers: R. E. McDaniel, chairman; M. W. Bowery, vice-chairman. May 29. Attendance 20.

West Virginia University

LIGHT BEAMS TO OPERATE TRAFFIC SIGNALS, by C. E. Higgins, student;

THE DU PONT AMMONIA PLANT AT CHARLESTON, W. VA., by H. A. Lewis, student;

SAFETY AT NIGHT FOR THE AVIATOR, by V. S. Monteith, student;

YOUR NIMBLE SERVANT—THE ELECTRON, by P. J. Johnson, student. May 5. Attendance 15.

Washington State College

THE VACUUM-TUBE VOLTMETER, by Mr. Emigh, student;

SHORT CIRCUITS ON MAIN TRANSMISSION LINES, by Mr. Holmes, student. May 8. Attendance 13.

Washington University

General discussion. May 14. Attendance 18.

University of Wisconsin

Film—"Electrical Measuring Instruments." April 28. Attendance 40.

Business meeting. May 26. Attendance 20.

Employment Notes

Of the Engineering Societies Employment Service

Men Available

ENGINEER, E. E. degree, age 30, married. Wide experience in layout, design, and research of small electrical parts, radio, motion picture and sound system apparatus. Desires position in laboratory or drafting room. A-1 references. Available immediately. Location, New York. B-5138.

GRADUATE MECHANICAL-ELECTRICAL ENGINEER, married. Nine years in public utility, testing, substation construction. One year with consulting engineer. Eight years electrical engineer, central department for group of large industrial plants; layout, operation, power distribution, economy. Three years electrical, process engineer, manufacturing plant: development, efficiency, supervision. Excellent references. East preferred. Available short notice. C-9312.

DEVELOPMENT AND RESEARCH ENGINEER, B. S. in E. E., M. S. in physics, 34, married. Four years' experience in one of largest research laboratories in electromagnetic problems and measuring instruments, knowledge of radio-frequency circuits and vacuum tubes, have patents granted, high designing and supervising skill. Desires position with future. C-9333.

CHIEF ELECTRICIAN AND MANUFACTURING ENGINEERING ASSISTANT, technical graduate, 34. Fourteen years' experience covering electrical installation, operation, and maintenance, and the manufacturing of mechanical and electrical parts. Desires position as plant electrician, testing of electrical machinery or apparatus, or engineering assistant. Moderate salary to start. Location, Northern New Jersey or vicinity. C-9305.

GRADUATE ELECTRICAL ENGINEER of Purdue University with eighteen years' experience in design, construction, estimating, costs, valuation and appraisal of power plants, substations, transmission lines and industrial plants including five years in heavy electric traction and rapid transit work. Open for opportunity with future. C-8256.

ELECTRICAL ENGINEER, 1930 graduate, 22, single. One year on the Westinghouse Student Course. Desires position as instructor in electrical engineering. Available school year 1931-1932. References. Location, immaterial. C-9311.

ELECTRICAL CONSTRUCTION ENGINEER, age 45; 25 years' experience. Has a broad technical knowledge, and extensive practical experience in commercial and industrial power and lighting construction including underground, power house and substation installations and railway electrification work. Has a thorough knowledge of estimating and valuation work and the supervising of construction forces. C-1140.

ELECTRICAL ENGINEER, 27, single, graduate of German college, six years' experience in design, research, and test on magnets, fractional horsepower motors, and control systems for mine hoists and elevators with leading American and German concerns. Desires position where knowledge of theoretical and practical is of importance. C-9310.

ELECTRICAL AND ILLUMINATING ENGINEER, 42 years old, 23 years' experience, electrician, superintendent, estimator, engineer, instructor. Power station, commercial and industrial building wiring, etc. Seven years in engineering for architects, office buildings, theaters, hotels, schools, hospitals, industrial buildings. Would like engineering position, or sales engineering. C-8460.

ELECTRICAL ENGINEER, graduate, E. E. degree, 28, married. Three years' experience relays, relay studies of large electric power and light utility, operating, New York City. Three years testing, design, and development work on new electrical appliances and materials. Experience includes considerable outside contact with leading electrical manufacturers. Available immediately. Location, New York City. B-8793.

ELECTRICAL ENGINEER, American. Street railway, main-line electrification, mining, and public utilities. Twenty years in Latin America as engineer and manager. Did considerable Diesel-engine and refrigeration work. B-5912.

ELECTRICAL ENGINEER, graduate Georgia Technology, 1930, cooperative plan, Westinghouse lighting courses. Cooperative work, alternate months, five years in substation maintenance and office engineering. Rebuilding transformers, switches, lightning arresters, work with electric furnaces, rectifiers, meters, motors, etc. Checking and mapping distribution systems, work orders, drafting, etc. Excellent references. Perfect health. Location immaterial. C-7847.

EXPERIENCED ELECTRICAL ENGINEER, graduate of two colleges, with twenty years of accomplishment in the electrical wire and cable industry; American, Protestant, and in good health. Would prefer to locate within 100 mi. of New York, though not essential. Can come for interview promptly; all references desired. B-9877.

MECHANICAL-ELECTRICAL ENGINEER, 46, single, 23 years' experience. Factory test, central station engineering, and sales work. Public utility operating engineer, assistant superintendent, and superintendent of construction, power and electric departments. Estimate and design work on substations, stations, relay systems, and lines. Specifications for buildings. B-271.

ELECTRICAL ENGINEER, 48, college graduate, married: 26 years' experience as designing, report, power and executive engineer with three engineering and construction firms, including system planning, design, construction cost estimating and construction supervision of power plants, substations and transmission facilities for public utilities and industrials. Studies of operating economics. B-4553.

ELECTRICAL ENGINEER, 26, single. Three years' experience with construction company, specializing in new construction. One and a half years' experience in light current work with leading telegraph company. Desires connection with company in construction or sales engineering departments. Location, New York City preferred. C-9290.

EXECUTIVE ELECTRICAL ENGINEER, 29, married. Six years' experience in design, and construction of transmission lines and substations. Now district manager for electrical manufacturing concern. Desires to make change. Available immediately. Location, immaterial. C-9324-315-C-4-San Francisco.

COLLEGE TRAINED ENGINEER, 29, married. Experienced in the design and estimating of distribution systems. Nine years' utility experience in responsible position. One and a half years' power cable engineering. Desires position with New York City utility, engineering or industrial company. Excellent references. C-9361.

HEAD OF ENGINEERING DRAWING DEPARTMENT of prominent university for seven years, will consider change to similar position. Available June 1931. B. S. in electrical engineering. Telephone and electrical experience. Practical machine designer. B-8248.

ELECTRICAL ENGINEER, graduate of University of Illinois, 1926. Two years' experience with Westinghouse, and two and a half years with public utility in planning division. Available immediately. C-9381.

GRADUATE ELECTRICAL ENGINEER, 29, married. One year eight months, Westinghouse test. Two and a half years' electrical construction with utility, engineering, supervision and reports. One year three months with consulting engineers. Desires position in planning department of public utility. No preference in location. C-7695.

ENGINEER, age 27, B. S. three years and seven months C. E. experience, desires position with hydroelectric project. Qualified for chief of party, transitman, estimator, assistant engineer. C-9382.

GRADUATE ENGINEER, age 35, two years' shop experience, fourteen years as draftsman in design of mechanical and electrical apparatus. Graduate of mechanical and electrical engineering courses of International Correspondence Schools. Willing to accept drafting or engineering position anywhere. C-9387.

EXECUTIVE OR STAFF ASSISTANT, engineering education. Fourteen years' broad experience with manufacturing, utility, and industrial surveys covering cost reduction, production planning, standards, wage incentives, scientific management methods, statistical control systems, expense and cost analysis. Capable organizer. Profitable assistant for busy executive. Prefers East. Consider any proposition. B-9122.

COMMUNICATION ENGINEER, 31, single. Experienced: telephone, radio installations; design, development of testing equipment for telephone, radio, sound-picture circuits; design, use of semi- and full-automatic testing circuits to eliminate human element in testing; industrial applications of photoelectric cells, thermionic tubes. Best references as to professional ability, personal integrity. Location, immaterial. Available immediately. C-9376.

ELECTRICAL ENGINEER, age 29, married, Pennsylvania State graduate 1925, with four years' railroad and subway signal installation experience as engineer, draftsman, and signalman, and one and a half years as assistant project engineer on railroad electrification; desires position in either of these lines. Location, anywhere. C-5089.

A-C. DESIGN ENGINEER, induction, and synchronous motors above 20 hp., alternators and auto-transformers. Experienced in the application of synchronous motors to compressor drive. Married. Location, immaterial C-9386.

PHYSICIST, middle-aged, experienced in industrial research, supervision of research, executive work, and teaching physics for engineering and other classes of students. Advanced degrees in physics from prominent Ameri-

can universities. Emphasis of electrical subjects in training and teaching. Stability and opportunity desired. Available on short notice. C-7900.

ELECTRICAL ENGINEER, EXECUTIVE, FOREMAN, 25 years' sound practical, technical, electrical and mechanical manufacturing experience in telephone and telegraph apparatus, instruments, printing machines, and pressed metal. Capable organizer and supervisor. Works and office system, estimating, cost analysis and accounts. Methods, tool design, machine and press-work, time-study rate-setting, moderate salary. Any location. C-3241.

DESIGN ENGINEER, twenty years' experience in design of a-c. machines covering polyphase induction motors of all sizes. Single-phase induction motors with inductance or capacity starting. Single-phase commutator motors of series, repulsion, and repulsion-induction type. Desires design or development work. Location, immaterial. C-8540.

1931 GRADUATE ELECTRICAL ENGINEER, B. E. E. University of Minnesota. Single, age 22. Special courses taken include design, radio and telephone. Desires position with any manufacturing or engineering firm. Location immaterial, opportunities and experience being main factors. Available immediately. C-9391.

INDUSTRIAL PRODUCTION MAN, electrical engineer, married, age 29, good health, graduated 1924, seven years' experience with large construction company on design, engineering, and construction of power and industrial plants. Wants production department job where electrical training and experience will count, with possibility of working into management. Location, New England. C-9384.

ELECTRICAL OR MAINTENANCE ENGINEER, 48, married, college graduate, 22½ years with present employer. Plant sold to large organization with its own engineers. Unusual experience in installation and operation of industrial substations, large synchronous motors, replacing 25 with 60 cycles and maintenance. Good mechanical, steam and process development experience. C-9399.

ELECTRICAL ENGINEER, B. S. degree, married, with about fifteen years' successful experience in the design and construction of transmission and distribution lines. Some teaching experience. Employed at present. Desires position as instructor in electrical engineering subjects or physics and mathematics. Excellent references. Location preferred, Middle West or West. C-9339.

ELECTRICAL ENGINEER, 27, single, B. S. E. E. Six months Westinghouse Graduate Student Course. Two years' laboratory work circuit interrupters, large power rectifiers, one and a half years' development work on standard magnetic controllers for steel mill applications, handling negotiations, estimating on motor-control apparatus. Familiar French language. Available immediately. Location, preferably East. C-9393.

ELECTRICAL ENGINEER, 36, single, citizen, desires position with engineering, manufacturing, or public utility concern. Six and a half years' experience in power plant and substation design. Two years in electrical furnace work. Highest education. Additional G. E. engineering course. Speaks foreign languages. Available on short notice. C-2710.

1929 ELECTRICAL DESIGN ENGINEER, 24, B. S. degree technical school. One year Westinghouse Student Course. Motor, transformer, turbo test experience. One year large synchronous motor design. Six months Westinghouse electrical design school. Desires position, design, research, development work with manufacturing company, or engineering department power company. Single with dependents. Location, immaterial. References. Available immediately. C-9410.

GRADUATE ELECTRICAL ENGINEER, Lehigh University (1930), married, 25, ten months engineering graduate student at Westinghouse, 22 summer months with National Tube Company. Desires position with public utility or manufacturing company where analytical and research ability is prime prerequisite. Available on two weeks' notice. Location, East or Middle West. C-9395.

1931 ELECTRICAL GRADUATE, midwest university, 22, single. Tau Beta Pi student. Desires connection with manufacturing or public utility concern. Location preferred, Middle West. C-9398.

ELECTRICAL ENGINEER, graduate Georgia Technology, 1930, age 23, married, now employed by large industrial corporation. Desires position with public utilities or with small industrial, United States or foreign. Available on short notice. C-9396.

ELECTRICAL ENGINEER, 31, married, college graduate, with six and a half years' experience consisting of: oil circuit breaker design; electrification of industrial plants; operation, maintenance and electrification of ore mines and steel mills. Thoroughly experienced on motor applications, transformer stations, switchboards, and distribution systems. Last one and a half years as electrical engineer with steel company. C-9414.

ELECTRICAL ENGINEER, 30, married, A. B. '22, B. S. in E. E. '24 (Harvard). G. E. Test, transformer design, development and technical writing; experience in factory planning, has taught evening classes; speaks German. Location preferred, East. C-9402.

ELECTRICAL ENGINEER, draftsman, experienced designer of light and power layouts of generating substations (indoor and outdoor) office buildings, factories and air ports. Technical school graduate and fifteen years' practical experience in the electrical and mechanical industry. C-7979.

REPRESENTATIVE available. Experienced sales engineer, electrical engineer, graduate. Desires high-grade electrical line of utility or heavy-duty industrial equipment. Eastern location. B-4067.

ELECTRICAL ENGINEER, 36, university graduate, married. Twelve years with large public utility as cadet, inspector and electrical tester (motors, transformers, cables, and electrical appliances). Also one and a half years' research on combustion control apparatus for instrument manufacturer and some engineering sales experience. Desires position with future near Philadelphia. References. C-8350.

ELECTRICAL ENGINEER, 1928 graduate of a recognized university, 26, single. One year central station testing, twenty months special apprentice on a large electrified railroad and seven months' telephone experience. Seeks engineering position where the above training and experience can be applied, free to locate anywhere. C-9112.

GRADUATE ELECTRICAL ENGINEER, S. B. from M. I. T. in 1927. Accidental injury has prevented employment. Now recovered. Has done considerable study since graduation in electrical engineering and physics, particularly radio and acoustics. Interested in most any kind of connection. Available at once. Single, age 25. C-9205.

SALES ENGINEER, distinctly electrical background, has good sales record, profit-minded, 39, single, likes people and contacts. Seeks permanent connection with leading company manufacturing controls for industrial applications. Conversant with thermoelectric and photoelectric principles. Specialized knowledge of conductors. Decided interest in distribution in broadest sense. Has proved executive ability. C-8797.

TECHNICAL GRADUATE, 32, with broad experience in operation, maintenance of substations, cable network, electric shovels. Substation testing. Speaks five languages. Desires connection with responsible company. Location, immaterial. B-9611.

ELECTRICAL ENGINEER, 36, married, 18 years' experience on power plants, transmission lines, substations, switchboards. Telephones, mine electrical equipment, motors, lighting, marine electrical work, draftsman. Five years electrical engineer wiring for power, light, telephones, signal systems, elevators for all types of buildings; also expert plumber, heater and tinner. C-9348.

GRADUATE ELECTRICAL ENGINEER, married, age 27, one year Westinghouse Student Course, two years' production control; two years' maintenance engineering. Desires permanent position with future. Will consider anything. Location, immaterial. C-9425.

GRADUATE ELECTRICAL ENGINEER, 1929, 22, single; 15 months on General Electric Test Course. Desires position with utility or manufacturing company or with concern doing consulting or construction engineering. Available immediately. Location, New England preferred. C-8028.

1931 GRADUATE ENGINEER, single, age 23. B. S. in E. E. from Lafayette College. Ten months' experience as assistant engineer with large belting company. Three months radio coil test. Prefers engineering position with engineering company or manufacturing company. Best of references. Location, immaterial. Available immediately. Slight knowledge of Spanish. C-9422.

GRADUATE ELECTRICAL ENGINEER, B. E. E. degree, 1930, 24, single; eight months on Westinghouse course. Assignments covered motor apparatus testing and refrigeration development work. Desires position with manufacturing concern or public utility. Working knowledge of Spanish. Initial salary and location secondary to opportunity. Reference. Available on short notice. C-9428.

GRADUATE ELECTRICAL ENGINEER, age 28, married, with eight years' experience in industrial plant construction and maintenance; railway electrification; power-plant design, estimating, and construction. Supervisory experience on construction and costs with contractor. Desires position with utility, manufacturer, or contractor, where ability to handle labor and produce results is a prerequisite. C-4428.

RECENT GRADUATE, 23, Pratt Institute in Industrial electrical engineering. Four years' practical experience in installation work and operation of substations. Specialized in motor control. Desires position with power company or related work in manufacturing or construction. Location, immaterial. C-9176.

ELECTRICAL-MECHANICAL ENGINEER, married, seven years' experience including G. E. Test, substation, and distribution with utility, development with electrical manufacturer, superintendent of small shop and operation of substations and motor rooms with a steel mill. C-1068.

MOTOR DESIGNER, graduate electrical engineer, 33, married, experienced in design of a-c. and d-c. motors and generators. Available immediately. C-8553.

ELECTRICAL ENGINEER, 27, Italian. M. S. Harvard University, Dr. Eng. University of Rome, exceptional theoretical and research grounding, five years' experience best firms electrical communication in Italy, United States America, Germany, England. Desires position for design or research work in Europe, England or continent. C-9431.

ELECTRICAL ENGINEERING TEACHER, B. S. and M. S. in E. E., G. E. Test, eleven years' teaching experience with recognized technical school. Desires permanent position. Available September. Excellent references. Age 36. C-5807.

ELECTRICAL ENGINEER with fifteen years' experience in design, construction, reports and editorial work. Available for publicity or editorial work on trade publications. References with leading engineering and publishing firms can be furnished. B-4022.

ELECTRICAL ENGINEER, technical college graduate, age 35. Ten to twelve years' mechanical and electrical experience in power plants, substations, transmission and distribution systems. Work includes G. E. Test and public utility engineering and operation. Desires position on operating staff of power company. Location, not particular. B-9782.

GRADUATE ELECTRICAL ENGINEER, 40. Eighteen years' experience in the manufacture of electrical wiring devices, including designing, development, testing, estimating, cost and production work. Four years with underwriters' laboratories in charge of a branch office making inspections, tests, examinations, and reports. Desires position with manufacturing concern, inspection bureau or experimental laboratory. C-8449.

ELECTRICAL ENGINEER, 37, single, B. Sc. Eng. London University 1920. Six years with British Thomson-Houston Company. Two years with power company in Pennsylvania. Three years with General Electric Company. Five years war service. Available at once. Any location. C-2248.

ELECTRICAL ENGINEER, one year's experience test course. Three years' experience transmission engineering department of large eastern electrical manufacturer. Desires position with utility company, teaching. Thoroughly familiar power system short-circuit, stability analyses, theory, application of method of symmetrical components. B. S. E. E. University of California 1927, 24, married. Available July first. C-9437.

ELECTRICAL ENGINEER, B. S. in E. E., age 30, married. Manufacturing and test experience. Public utility transmission and distribution engineering experience. Sales experience. Executive and teaching ability. Salary expected, open to offer. Position desired, open to offer. Available at once. C-7867.

ELECTRICAL ENGINEER, 28, married, four years out. One year power utility course, three years telephone and talking pictures. Previous experience as commercial radio operator. Would be valuable to concern requiring capable engineer. Position must be permanent with future. Location not a guiding factor. Best of references are available. C-7902.

ELECTRICAL ENGINEER, 30, married, graduate 1924. Two years' postgraduate work, advanced electrical theory, two and a half years' writing specifications for the manufacture and installation of telephone repeater offices, one year at generator design and two years as field engineer for public utility. Desires position with future. C-951.

ELECTRICAL ENGINEER, B. S. in E. E., single, age 27. Five years' experience with electrical manufacturer on the development, design, and application of lightning arresters. Also close contact with lightning field investigations of recent years; familiar with this work and its results. Position with operating company preferred. C-9449.

TEACHER OF ELECTRICAL ENGINEERING, 37; married. Thirteen years' teaching experience; many summers spent in practical work. B. S. in E. E. and E. E. degrees. Taught all electrical engineering subjects as well as physics, electric thermodynamics, descriptive geometry, mechanical drawing. Sixteen months' general management large college radio station. Available immediately. C-9445.

ELECTRICAL ENGINEER, E. E. graduate 1924, age 29, married. One year telephone maintenance, two years General Electric Test, one year research, four years system operator large public utility. Experienced radio installation and maintenance. Desires position along line of experience with advancement opportunities. Location preferred, vicinity of greater New York. Available now. C-4183.

ELECTRICAL ENGINEER, 22, single, university graduate '31. Desires junior position in test or design departments of power machinery manufacturing concern. Experience limited. Location preferred, East. Available on short notice. C-9447.

ELECTRICAL ENGINEER, graduate 1931, single. Three years' cooperative experience in public utility maintenance work. Four summers' experience in ice-cream industry. Desires opening offering steady work and possibility of advancement. Location and type of work secondary. Available at once. C-9418.

ELECTRICAL ENGINEER, class '31, from a southern technical institute desires a part or full-time position as instructor in mathematics or electrical engineering with the privilege of carrying graduate work. C-9415.

1931 GRADUATE ELECTRICAL ENGINEER, age 26, industrious, reliable, Russian and American education seeks permanent connection. Location, immaterial. C-9455.

ELECTRICAL ENGINEER, 43, married, twenty years' electrical, power, and industrial plants experience in construction, maintenance of distribution, and transmission lines. Desires position with public utility or industrial plant. Can qualify as electrical superintendent. Used to handling men. Available on short notice. Canada preferred but would consider other location. C-9459.

ELECTRICAL ENGINEER, B. S. E. E. '30, age 22, single. One year General Electric Test. Desires position in either sales or operating department of public utility, or in any electrical line offering a future. Location, immaterial. Available at once. C-9454.

GRADUATE IN ELECTRICAL ENGINEERING, 1931, age 26, single, has B. S. in E. E. One year of electrical testing with large utility company. One year of electrical drafting of power and control switchboards. Three years' work in practical electricity. Interested in construction and supervision of small plants. Available at once. Location, anywhere. C-9457.

JUNIOR ENGINEER, 1931 graduate, B. S. E. E., University of Alabama. Desires position with utility, construction, manufacturing company. Location, immaterial. Experienced in power-plant and building installation and industrial control, having been employed for eight summer months and one full year, first as electrician helper and later as first-class electrician. C-9446.

RAILROAD ELECTRICAL ENGINEER, college graduate; A. I. E. E., A. S. M. E. A. E. R. A., A. R. A. membership; six years' design, construction, and operating experience on two large American railroad electrifications; familiar with American and European practices regarding motive power, substations, catenary, transmission lines. Excellent references; young. Desires position with consulting firm, railroad, power company, or manufacturer. C-8463.

GRADUATE in electrical engineering, class of '29, 25 and single; fourteen months G. E. Test. Four months' experience in research. Desires position in engineering department of utility or manufacturing company offering a future. Available at once. Location, eastern United States. C-9003.

ELECTRICAL ENGINEER, 32, technical graduate, twelve years' experience with public utilities; familiar with operation, design and construction of transmission lines, substations, steam and hydro-generating stations. Familiar with field and office work. Desires responsible position with holding company, operating company or consulting engineer. Location, immaterial. Available immediately. C-6401.

ELECTRICAL ENGINEER, 36, married, technically trained, fifteen years' experience covering complete engineering design, supervision of power plants, high-voltage switching stations, substations, transmission lines, including estimates, specifications, purchase of equipment, supervision of construction. Experience covers system development, investigations of systems for load conditions, expansion, relay and stability studies, frequency and load control. C-7194.

ELECTRICAL ENGINEER, E. E. from European electrotechnical university, M. S. from University of Michigan; 9 years' experience with public utilities in construction, maintenance, and design; three years with Westinghouse switchboard department, including engineering school; desires position of designing engineer with public utility or large industrial concern. C-4976.

ELECTRICAL ENGINEER, 22, single. E. E. degrees, 1929; M. S. in E. E. from M. I. T., 1931; 20 months' General Electric Test course. Desires position involving electric design and development or as instructor in electrical engineering. Location preferred, East. Available immediately. C-9462.

JUNIOR ENGINEER, 1930 graduate, B. S. degree in E. E., associate member of Sigma Xi. Eight months' practical experience in research, design, and testing with large radio concern. Desires position as engineering instructor or in any electrical line offering a future. Eastern location preferred. Salary secondary to opportunity. C-9300.

SALES ENGINEER, 36, married, graduate electrical engineer, fifteen years' experience, includes sale signal and telephone apparatus, control and charging equipment, light machinery and its design. Also field supervision, organizing, technical writing, engineering building projects, layouts, specification writing, estimating, teaching, lecturing. Available within two weeks. Location, vicinity New York City. B-247.

ELECTRICAL, STEAM, AND MECHANICAL SUPERVISOR, 33, married, twelve years' experience in industrial and power plants. For the past four years has had charge of all steam and electrical power and maintenance of large industrial plant consuming 4,000 kw. and 1,200 hp. steam. B-7004.

GRADUATE ELECTRICAL ENGINEER, 30, married. Seven years' practical experience

in design and construction of substations, electric distribution both overhead and underground, with relay application, industrial power layout, lighting design, familiar with the latest developments in these lines. Available immediately. B-6384.

ELECTRICAL ENGINEER, bachelor and master degrees; fourteen years' peculiarly broad experience in test, research and development, standardization, consultation, university teaching, executive work, personnel; familiar with both power and radio equipment and practise. Stability and opportunity primary; initial salary and location secondary. Available at once. C-4591.

COLLEGE GRADUATE, 27, single, B. S. in E. E. Eighteen months General Electric Test, 22 months telephone equipment engineer. Desires position in manufacturing or utility company. Location preferred, Middle West; however, not essential. Available at once. C-9285.

Membership

Recommended for Transfer

The board of examiners, at its meeting of June 5, 1931, recommended the following members for transfer to the grade of membership indicated. Any objection to these transfers should be filed at once with the national secretary.

To Grade of Fellow

MOWBRAY, WILLIAM J., cons. elec. engr., Cranston, R. I.

WELLER, GEORGE L., equip. and bldgs. engr., The Chesapeake & Potomac Tel. Co., Washington, D. C.

To Grade of Member

ASHMORE, JOSEPH, dist. mgr., British Elec. Repairs, Ltd., Birmingham, Eng.

BIEGEL, EARL J., asst. supt. elec. dist., Memphis Pwr. & Lt. Co., Memphis, Tenn.

BOROKHOVICH, JOHN A., asst. engr., Brooklyn Edison Co., Brooklyn, N. Y.

CLARK, EDWIN E., asst. prof. of elec. engg., South Dakota State School of Mines, Rapid City, S. D.

EVERITT, WILLIAM L., assoc. prof. elec. engg., Ohio State University, Columbus, Ohio.

GRAHAM, ROBERT W., asst. elec. supt., Bethlehem Steel Co., Buffalo, N. Y.

GRISCOM, SAMUEL B., central sta. engr., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

HAINES, THOMAS H., supt. maint. of lines dept., Edison Elec. Illuminating Co. of Boston, Mass.

HARTMAN, HOWARD W., design engr., General Elec. Co., Schenectady, N. Y.

HELLERN, BERNHARD, production engr., National Industri, Drammen, Norway.

JONES, EVAN R., transm. engr., Mountain States Tel. & Tel. Co., Denver, Colo.

KAIGHN, HERBERT E., cons. engr., Wilmington, Del.

KLEIN, HARRY R., Jr., engr., Brooklyn Edison Co., Inc., Brooklyn, N. Y.

LAKE, MARSHALL E., pwr. sales engr., Duke Power Co., Charlotte, N. C.

MIER, C. WALKER, engr., Southwestern Bell Tel. Co., Oklahoma City, Okla.

MILBURN, LOYAL R., asst. elec. engr., Great Lakes Steel Corp., Detroit, Michigan.

MOREHOUSE, ADEN K., toll service supervisor, Pacific Tel. & Tel. Co., Portland, Ore.

OVEROCKER, RANDALL H., asst. engr., New Jersey Bell Tel. Co., Newark, N. J.

PURDY, HARRY E., engg. asst., Brooklyn Edison Co., Brooklyn, N. Y.

SPOONER, HOWARD M., field engr., United Engineers and Constructors, Inc., Newark, N. J.

STEBBINS, FREDERICK O., engr., General Elec. Co., Schenectady, N. Y.

YERKES, EARLE P., engineer of equipment, Bell Telephone Co. of Pa., Philadelphia, Pa.

YOUNG, HADLEY E., supt., East Canada Creek Hydro Sta., New York Power & Light Corp., Little Falls, N. Y.

ZEBLEY, JUNE S., supervisor of inspectors, Elec. Dept., Dist. of Columbia, Washington, D. C.

Applications for Election

Applications have been received by the secretary from the following candidates for election to membership in the Institute. Unless otherwise indicated, the applicant has applied for admission as an Associate. If the applicant has applied for direct admission to a grade higher than Associate, the grade follows immediately after the name. Any member objecting to the election of any of these candidates should so inform the secretary before July 31, 1931.

Balliett, C. G., Rochester Telephone Corp., Rochester, N. Y.

Balmford, J. A. (Member) Columbia University, New York, N. Y.

Barksdale, G. R. (Fellow) Tennessee Electric Power Co., Chattanooga, Tenn.

Brobson, J. F., Detroit Daily Mirror, Detroit, Michigan

Bulkley, O. R., Southern California Edison Co., Long Beach, Calif.

Clark, J. H., Southern California Telephone Co., Los Angeles, Calif.

Cline, J. E., Southern Indiana Tel. & Tel. Co., Seymour, Indiana

Elinson, W. L., Ontario Paper Co., Ltd., Thorald, Ont., Canada

Ennis, A. G., Philadelphia & Reading Coal & Iron Co., Pottsville, Pa.

Finfer, Sidney, Police Department, City of New York, New York City, New York

Finley, R. F., New York Central Lines, New York, N. Y.

Foernsler, L. O., 11113-113th St., Richmond Hill, N. Y.

Gray, L. T., Jr., Pacific Gas & Electric Co., San Francisco, Calif.

Hansen, F. A. (Member) Holophane Co., Inc., Los Angeles, Calif.

Hery, V. D., Index Machinery Corporation, Cincinnati, Ohio

Karle, J. J., Kny-Scheerer Corp., Long Island City, N. Y.

King, C. J., Montaup Electric Co., Somerset, Mass.

Korik, C. (Member) Home Engineering Co., Philadelphia, Pa.

Lee, A. C. (Member) Duke Construction Company, Durham, N. C.

Long, W. F., Union Electric Light & Power Co., St. Louis, Mo.

Mallory, D. D., Valparaiso University, Valparaiso, Indiana

Miller, T. H., 1575 Washington Street, San Francisco, Calif.

Mitchell, I. A., Kenyon Transformer Co., Inc., New York, N. Y.

Mowry, C. H., The New York Telephone Co., Brooklyn, New York

Murray, J. S. (Member) Follansbee Brothers Co., Follansbee, W. Va.

Neuschot, R. (Member) Thompson-Starrett Co., Inc., New York City, N. Y.

Nicol, W. C., Hartford Steam Boiler Inspection & Insurance Co., Chicago, Ill.

O'Handley, J. A., Western Electric Co., Kearny, N. J.

Rathbun, V. R., Dept. of Public Utilities, Tacoma, Wash.

Reynolds, F. N. (Member) General Electric Co., Philadelphia, Pa.

Robinson, F. W., Stanton Oper. Co., Pittston, Pa.

Ruddell, L., Kansas City Power & Light Co., Kansas City, Mo.

Schwabacher, G. P., General Electric Co., Bridgeport, Conn.

Seaman, F. D., Dominion Electric Power Ltd., Regina, Sask., Can.

Smith, C. C., General Electric Co., Bridgeport, Conn.

Steates, E. F., 11 Clark Place, Utica, New York

Stevens, O. L. Erie County Electric Co., Erie, Pa

Stilwell, W. E., Jr., Union Gas & Electric Co., Cincinnati, Ohio

Stone, R. D., State Trade School, Willimantic, Conn

Stretch, M. W., Westinghouse Elec. & Mfg. Co., Mansfield, Ohio

Thomson, G. T., Hydro Electric Power Commission of Ont., Leaside, Ontario, Canada

Van Horne, J. C., Powell, Wyoming

Wannag, V. E., Western Electric Co., Kearny, N. J.

Welch, W. M., Bell Telephone Co. of Penna., Philadelphia, Pa.

Wold, T., Smith & Stone, Ltd., Georgetown, Ont., Canada

45 Domestic

Foreign

Barnes, H. W., Ferranti Ltd., Aldwych, London, Eng.

Ganpathi, R., The Cochin Electric Co. Ltd., Cochin, South India

Cheryan, P. C., Siemens-Schuchert-Werke A. G., Berlin, Germany

Phillips, F. A., Electrical & Radio Service Co., Hurstville, Australia

Ram, A., Renala Hydro Electric Installation, Renala Khurd, Dist. Montgomery, Punjab, India

Roth, A., Kabelfabrik und Drahtindustrie Aktien-Gesellschaft, Vienna, Austria

Shinohara, K., Ministry of Communication, Tokyo, Japan

Taylor, M. G., c/o Venezuela Power Co., Ltd., Barquisimeto, Venezuela, S. America

8 Foreign

Engineering Literature

New Books

In the Societies Library

AMONG the new books received at the Engineering Societies Library, New York, during May are the following which have been selected because of their possible interest to the electrical engineer. Unless otherwise specified, books listed have been presented gratis by the publishers. The Institute assumes no responsibility for statements made in the following outlines, information for which is taken from the preface or text of the book in question.

FACHAUSDRÜCKE DER SCHWEISSTECHNIK. Deutsch-Englisch-Russisch. Berlin, V. D. I. Verlag, 1931. 31 pp., 6 x 4 in., paper, 2-r. m.——This little dictionary is intended to supplement the general engineering dictionaries by providing a list of the welding terms in general use, especially those of recent coinage. The book has been compiled by the welding committee of the German Engineering Society and is unusually successful in providing exact equivalents for the terms.

MACMILLAN TABLE SLIDE RULE. By J. P. Ballantine. N. Y., Macmillan Co., 1931. Tables, 11 x 9 in., paper, $.50.——A set of four numerical tables and four slides, by means of which the arithmetic problems that arise in trigonometry and engineering may be solved without calculation. The charts answer the purpose of an ordinary slide rule. Three to four places can be read direct; five or more may be had by interpolation.

RECORDING SOUND FOR MOTION PICTURES. Edit. by Lester Cowan for the Academy of Motion Picture Arts and Sciences. N. Y., McGraw-Hill Book Co., 1931. 404 pp., illus., diagrs., charts, tables, 9 x 6 in., cloth. $5.00.——A textbook upon the technique of making sound pictures, prepared by a number of experts. The equipment for recording and reproducing sound is described in detail, as are also the manipulation of the film and the problems of studio acoustics and of recording. The book is the first to present a systematic account of practise in its field.

MECHANICAL LABORATORY METHODS. 4th edit. By J. C. Smallwood and F. W. Keator. N. Y., D. Van Nostrand Co., 1931. 386 pp., illus., diagrs., charts, tables, 10 x 6 in., cloth, $3.50.——Directions are given for testing and calibrating scales, calorimeters, brakes, fluid meters and other instruments, for analyzing fuels and determining their heat value, and for testing engines, boilers, pumps, refrigerating machinery, lubricants and electrical machinery. The principles underlying the methods are given, and the directions are clear and concise. This edition has been revised and rearranged to conform with modern requirements.

SPONS' ELECTRICAL POCKET-BOOK. By W. H. Molesworth. Lond., E. & F. N. Spon; N. Y., Spon & Chamberlain. 4th edit., 1931. 401 pp., diagrs., charts, tables, 7 x 4 in., leather, $2.50.——Small enough to be carried in a coat pocket, this work of some 400 pages contains a careful selection of material frequently needed for reference by engineers, particularly those engaged in central station work, transmission and railroading.

THEORY AND PRACTICE OF RADIO FREQUENCY MEASUREMENTS. 2nd edit. By E. B. Moullin. Lond., Charles Griffin & Co., Ltd.; Phila., J. B. Lippincott Co., 1931. 487 pp., illus., charts, diagrs., tables, 9 x 6 in., cloth. $12.50.——A practical laboratory guide covering all the measurements usually made and giving clear, detailed methods for making them. The new edition has been almost doubled in size and largely rewritten.

ORDER FORM FOR REPRINTS OF FULL PAPERS ABRIDGED IN THIS ISSUE OF *ELECTRICAL ENGINEERING

(July 1931) Number	Author	Title
☐ 31-4	L. V. Bewley	Traveling Waves on Transmission Systems
☐ 31-9	J. J. Torok	An Experimental Lightning Protector for Insulators
☐ 31-10	R. R. Pittman and J. J. Torok	Lightning Investigation on a Wood Pole Transmission Line
☐ 31-20	Philip Sporn	1929 Lightning Experience on the 132-Kv. Transmission Lines of the Am. Gas and Elec. Co.
☐ 31-42	J. C. Dowell	Attenuation and Successive Reflections of Traveling Waves
☐ 31-57	F. A. Cowan	Recent Developments in the Operation of Overseas Radio Telephone Service
☐ 31-79	Philip Sporn and W. L. Lloyd, Jr.	1930 Lightning Investigations on the Transmission System of the Am. Gas and Elec. Co.
☐ 31-82	C. L. Fortescue and R. N. Conwell	Lightning Discharges and Line Protective Measures
☐ 31-85	Otto Brune and J. R. Eaton	Experimental Studies in the Propagation of Lightning Surges on Transmission Lines
☐ 31-86	I. W. Gross and J. H. Cox	Lightning Investigation on the Appalachian Elec. Pwr. Co.'s Transmission System
☐ 31-87	W. W. Lewis and C. M. Foust	Lightning Investigation on Transmission Lines—II
☐ 31-88	F. W. Peek, Jr.	Lightning, Characteristics—Induced Voltages—Direct Strokes—Coordination—Transmission Line Design
☐ 31-89	Edgar Bell and A. L. Price	Lightning Investigation on the 220-Kv. System of the Penn. Pwr. & Lt. Co. (1930)

*Members, Enrolled Students and subscribers are entitled to one complete copy of any paper abridged if it is requested within one year from date of its publication in ELECTRICAL ENGINEERING. Thereafter a charge of twenty-five cents per complete copy will obtain.

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Selected Items From Engineering Index Service

SELECTED references to current electrical engineering articles from Engineering Index Service's review of some 2,000 technical periodicals are given in the following columns.

All articles indexed are on file in the Engineering Societies Library, New York, which will furnish photoprints of any article at a cost of 25 cents per page or make translations of foreign articles at cost.

Ammeters

HIGH FREQUENCY. A Method of Comparing Ammeters At Very High Frequencies. C. L. Fortescue and L. A. Moxon. *Sci. Instruments—Jl.*, vol. 8, no. 3, Mar. 1931, pp. 94-97, 5 figs. Considerable difficulty has been experienced in comparing ammeters at frequencies above one million cycles per second with reasonable degree of accuracy; means of overcoming these difficulties are described and final arrangement is reliable up to frequencies of 100 million to within accuracy of 2 per cent.

Brushes

COMMUTATOR. Double Brush-Holders Improve D-C. Machine Operation. A. M. Harrison. *Power*, vol. 73, no. 15, Apr. 14, 1931, pp. 586-587, 3 figs. Under certain conditions use of double brush-holders on d-c. machines is advantageous, while on other machines they may be objectionable.

Cables

PAPER INSULATED. The Manufacture of Lead-Covered Paper-Insulated Telephone Cable. J. R. Shea. *Mech. Eng.*, vol. 53, no. 4, Apr. 1931, pp. 277-283, 17 figs. Particulars regarding new developments comprising direct application of wood-pulp insulation, improved cable stranding, vacuum drying, and central melting of large quantities of lead alloy and its distribution through piping to number of sheathing presses. Before "Three-M" (Management, Materials, Maintenance) Congress, Cleveland, Ohio.

RUBBER INSULATED. Ueber Maschinen zur Herstellung von Kabeln (Machines for Manufacture of Cables). M. Pollman. *Gummi-Zeitung*, vol. 45, nos. 21 and 22, Feb. 20, 1931, pp. 876-877 and Feb. 27, pp. 914-916, 7 figs. Particulars of so-called wire-covering machines of both vertical and horizontal type for covering of thin and thick conductors. See reference to previous articles by author in same journal, in Engineering Index 1930, p. 545, and Engineering Index 1929, p. 603.

SUBMARINE. Some Economic Factors in the Design of Single Core Submarine Cables for Carrier Telephony. J. R. Vezey. *Elec. Communication*, vol. 9, no. 4, Apr. 1931, pp. 217-221, 4 figs. Having decided on length, attenuation, and number of speech channels for any cable, relative proportions of weights of central conductor, dielectric and return conductor to obtain lowest cost can be varied over wide range; further feature, brought out by study, is that maximum length of cable over which it is possible to work fixed number of channels, varies relatively little within limits of practical sizes of core.

TELEPHONE. Buried Tape-Armored Exchange Cable. C. W. Nystrom. *Telephony*, vol. 100, no. 14, Apr. 4, 1931, pp. 22-25, 10 figs. New method of underground exchange construction applicable to suburban residential areas; method and materials used in burying tape-armored exchange cable; cable placed in either hand or machine-dug trench.

Circuits

HIGH-VOLTAGE. A Note on the Timing of Electrically Independent Transient Circuits for High-Speed Oscillographic Work. L. B. Snoddy and J. C. Street. *Gen. Elec. Rev.*, vol. 34, no. 4, Apr. 1931, pp. 258-259, 3 figs. Method for initiating discharge in high-voltage circuits at definite time has been developed and applied to lightning generator voltages up to 430 kv.; method uses combination of over-voltage and irradiation by ultra-violet light; it has advantage that it requires no electrical connection between tripping circuit and high-voltage side of impulse circuit.

Circuit Breakers

ELECTRIC. Oil-Less Switchgear. *Elecn. (Lond.)*, vol. 106, no. 2760, Apr. 24, 1931, pp. 611-612, 3 figs. Siemens-Schuckert works and A. E. G. have, as result of experimental work in their laboratories, put on to market high capacity oil-less switches, thus showing their confidence in methods by which they have tackled problem; switches of both these types were on view at Leipzig Technical Fair.

Conductivity

The Electrical Conductivity of Some Bismuth Alloys at Low Temperatures. J. C. McLennan, J. F. Allen and J. O. Wilhelm. *Roy. Soc. Canada—Trans.*, vol. 24, pt. 1, section 3, May 1930, pp. 25-32, 1 fig. Investigation to find how superconducting point of lead would be affected by alloying this metal with bismuth and with antimony; also to determine superconducting point of some of fusible alloys of which bismuth is constituent. Bibliography.

Control

CHEMICAL PLANTS. Centralized Control Improved Production. A. J. A. Peterson. *Instruments*, vol. 4, no. 2, Feb. 1931, pp. 51-53, 2 figs. Large chemical plant in Niagara Falls applied to its problem of machine and load control, same principles used in central station industry; in this plant, operator must control and supervise 10 to 14 manufacturing units, all forming heavy electrical loads, and must supervise incoming supply as well.

ELECTRIC HEATING. Radiation-heating Control. C. G. Heys Hallett. *Elec. Rev.*, vol. 108, no. 2785, Apr. 10, 1931, pp. 626-627, 4 figs. Remarkable economies in current consumption and gains in personal comfort result from use of radiation thermostat or "Eupatheostat" as compared with ordinary air thermostat.

Controllers

Misapplications of Control Equipment. H. C. Jenks. *Indus. Eng.*, vol. 89, no. 3, Mar. 1931, pp. 110-113, 4 figs. Putting control equipment in service for which it was not designed frequently causes trouble; practical discussion of control equipment breakdown and methods of prevention.

Currents

HAZARDS. Note sur la tension non dangereuse des courants électriques (Safe Voltages of Electric Currents). Feraud. *Société Francaise des Electriciens—Bul.*, vol. 1, no. 3, Mar. 1931, pp. 288-301 and (discussion) 302-305. Qualitative definition of safe voltages; influence of characteristics of source on hazards, influence of outside circumstances at source on hazards; dangerous current; quantitative analysis of safe voltages; conclusions.

Dielectrics

X-RAY ANALYSIS. X-Ray Studies of Motions of Molecules in Dielectrics Under Electric Stress. R. D. Bennett. *Franklin Inst.—Jl.*, vol. 211, no. 4, Apr. 1931, pp. 481-487, 7 figs. Experiments at Ryerson Physical Laboratory lead to conclusion that molecular group state of liquid is accentuated as liquid solidifies leading to definite crystalline structure, which can be strongly oriented by electric field; it is concluded that X-ray methods may prove useful tool in investigation of molecular motions in dielectrics.

Electricity

Electricity—What It Is and How It Acts—L. A. W. Kramer. *Power Plant Eng.*, vol. 35, no. 9, May 1, 1931, pp. 514-516. Electron and proton as factors in explaining radiation from sun and stars.

Electric Drive

BLOOMING MILLS. 5000 Hp. D-C. Motor Drives New Algoma Rail and Structural Mill. A. F. Kenyon. *Elec. News*, vol. 40, no. 7, Apr. 1, 1931, pp. 54-56, 4 figs. Demands of Canadian railways for longer and heavier steel rails has necessitated complete rebuilding and electrification of the rail and structural mill of Algoma Steel Corporation, Sault Ste. Marie, Ont.; initial rolling of 26 in. x 26 in.—13,500 lb. ingots is in electrically driven 35 in. reversing blooming mill, ingots being reduced to 10 in. x 10 in. and smaller blooms, depending upon product being rolled in finishing mills.

PAPER AND PULP MILLS. New Mill Drive at Smith Paper Co. Aids Heat Balance. R. A. Packard. *Power*, vol. 73, no. 13, Mar. 31, 1931, pp. 504-506, 6 figs. Synchronous motor on turbine shaft permits unit to be governed by low-pressure steam demand; surplus or efficiency of power being taken by utility system; diagram of steam distribution at Columbia mill; diagram of main electrical connections.

PUMPS. Selecting the Motor to Suit the Pump. E. C. Dieffenbach. *Power*, vol. 73, no. 17, Apr. 28, 1931, pp. 656-659, 6 figs. Starting conditions and nature of various loads determine motor and control: to choose wisely, both motor and pump characteristics must be understood; drives for reciprocating, centrifugal, rotary and screw pumps are discussed; characteristic curves.

ROLLING MILLS. Modernizing Rolling Mills Electrically. *Iron and Steel Industry*, vol. 4, no. 7, Apr. 1931, pp. 235-238, 4 figs. Examples of modern main drives for rolling mills carried out by English Electric Co.; sheet-mill and merchant-mill drives; large motor for Brown Bayley and Co.; exciter set for mill motor; strip mills and cold-roll drives; heating of sheet-mill rolls; special tube-mill installation; frequency standardization; switchgear.

WIRE DRAWING MACHINES. Electric Equipment for Wire Drawing. T. R. Rhea. *Wire*, vol. 6, no. 5, May 1931, pp. 165-167-170 and 185, 8 figs. Various types of machines and type of motors and control which experience has determined as most suitable.

Electric Equipment

AUTOMOBILES. Modern Electric Equipment of Motor Vehicles. V. A. Karpov. *Elektrichestvo*, no. 2, Feb. 1931, pp. 66-76, 10 figs. Systematic review of electric equipment of motor cars, tractors, and motorcycles; typical schemes of electric equipment for modern motor vehicles of different systems applied in U.S.S.R. and other countries; power-supply systems and electric accessories are critically described. (In Russian.)

MAINTENANCE AND REPAIR. Maintenance Methods for Electrical Equipment. E. L. Richards. *Power Plant Eng.*, vol. 35, no. 6, Mar. 15, 1931, pp. 360-362, 3 figs. Systematic maintenance schedule includes inspections and shutdowns and anticipates repair work; importance of inspection schedule and records; maintenance record forms.

Electric Lines

HIGH TENSION DESIGN. Design of 110- and 132 Kilovolt Steel Tower Transmission Lines. *Nat. Elec. Light Assn.—Report*, no. 17, Mar. 1931, 16 pp., 3 figs. Condensed discussion of more important factors entering into design of 110- and 132-kv. steel tower transmission lines showing what items enter into transmission line specification together with some indication of typical practise with respect to each item, *i. e.*, location, electrical clearances, conductors, tower loading, transmission tower specifications; insulation; telephone lines.

PROTECTION. Protection of Rural Lines. *Elecn. (Lond.)*, vol. 106, no. 2760, Apr. 24, 1931, p. 610. Discussion by Overhead Lines Association on control and protection of rural lines; standard nomenclature is needed; oil and air break switches compared. Before Instn. Elec. Engrs.

Electric Power

RAYON PLANTS. Electrification of a Rayon Mill. *Elec. Times*, vol. 79, no. 2055, Mar. 12, 1931, pp. 473-475, 6 figs. Power generation and distribution in Sunsheen's Mills, Ballymena, Ireland, with special reference to problem of cabling and wiring; current is generated by means of two steam-driven turbine-generators, main unit of 820-kw. output, at 400 volt, 50 cycle, three-phase, neutral point being brought out, so as to provide 230 volts for lighting; second turbine set is of 100 kw.; steam is raised in three Lancashire boilers 8 ft. by 30 ft., working at 180-lb. pressure and superheated 150 deg. fahr.

Electric Towers

TESTING. Testing Full-Size Transmission Towers. N. B. Obbard. *Eng. News-Rec.*, vol. 106, no. 18, Apr. 30, 1931, pp. 735-737, 4 figs. Description of plant of American Bridge

Co., in Pittsburgh, equipped to test towers up to 100 ft. in height, either on fixed grillage or on their own earth anchors; wind and conductor loads applied simultaneously at as many as seven points by pulling rig actuated by 50,000-lb. mechanical screw.

Electrodes

POTENTIALS. The Nernst Equation—A New Equation for Electrode Potentials—I, M. Meyer. *Chem. News*, vol. 142, no. 3701, Mar. 20, 1931, pp. 179-183, 2 figs. Many corrections have been applied to concentration of "active" material in effort to secure better agreement; all save "activity" coefficient fail; textbooks still make curious comments about equation; since electromotive force measurements may be made with great precision it may be of interest to examine some and also another possible equation which, however, because of its nature, seems only of academic interest.

Engineering

BUSINESS RELATIONS. Shall We Revise Our Conceptions of Engineering Functions. L. E. Jermy, *Machine Design*, vol. 3, no. 5, May 1931, pp. 23-25, 2 figs. Study of relationship and responsibilities of engineer to principal departments of industrial organization; chart illustrates relationships of chief engineer.

EDUCATION. A Suggestion for Engineering Education, L. E. Moore, *Boston Soc. Civil Engrs.—Jl.*, vol. 18, No. 4, Apr. 1931, pp. 95-102. Development of engineering education; engineering specialties; search for school to meet ideals for training; suggested course for students in engineering, natural philosophy, and sciences; author criticizes existing system for turning out men who are too often narrow technicians instead of scientifically educated gentlemen, capable of taking hold of any branches of applied science and by study specializing in them.

INFLUENCE ON CIVILIZATION. Technology and Material Progress. W. R. Whitney, *Science*, vol. 73, no. 1877, May 8, 1931, pp. 482-486. It is claimed that accumulated data of all material progress never were so great and never so uniformly appreciated; those who are interested in technical progress look at it as continuous, but do not necessarily overrate its importance; there must be parallel advance for higher values in man. Before Am. Philosophical Soc.

Engineers

RESPONSIBILITY. The Responsibility of the Engineer, R. V. Wright. *Engrs. and Eng.*, vol. 48, no. 4, Apr. 1931, pp. 73-75. Economist as well as engineer has been sticking too much to cold facts and seems to have overlooked fact that most precious factor in industry, human element, must be handled in entirely different way from materials and natural forces; now great problem of engineer is to deal with human life in industry. Before Engrs. Club.

Exciters

TURBO-GENERATORS. Turbo-Generator Exciters, W. Sharp. *Elec. Times*, vol. 79, no. 2059, Apr. 9, 1931, pp. 659-660, 6 figs. Probable lines of progress and subsequent developments in connection with manufacture of turbo-generator exciters; subject as direct bearing upon possibility and advisability of making continuous-current exciter remote from turbo-generator.

Furnaces

ANNEALING. Electric Annealing of Aluminum. *Foundry Trade Jl.*, vol. 44, no. 763, Apr. 2, 1931, p. 244, 1 fig.; see also *Metal Industry (Lond.)*, vol. 38, no. 14, Apr. 3, 1931, p. 364, 3 figs. and *Mech. World*, vol. 89, no. 2310, Apr. 10, 1931, p. 343. To facilitate precise annealing of aluminum sheets on large scale, General Electric Co., has installed large single-track multi-car type electric annealing furnace which has effective hearth area 24 ft. long by 7 ft. 5 in. wide in works of Aluminum Corp., Dolgarrog, Carnarvonshire; furnace has electric loading of 150 kw., heating elements arranged to ensure phasal balance on 440-volt, 3-phase, 50-cycle supply.

HEAT TREATING. Bright Anneals in Artificial Atmospheres, J. C. Woodson. *Elec. Jl.*, vol. 38, no. 4, Apr. 1931, pp. 246-247, 3 figs. Possibilities of annealing in artificial atmospheres, which process is still in development stages, are not known; however, certain surface conditions can be obtained that reduce number of subsequent operations and greatly increase die life and reduce machine work; various types of electric furnaces are illustrated.

STEEL MAKING. Montreal Plant Produces Electric Furnace Steel in Large Quantities. *Can. Machy.*, vol. 42, no. 5, Mar. 5, 1931, pp. 27-30, 5 figs.; see also *Iron and Steel Canada*, vol. 14, no. 2, Feb. 1931, pp. 30-32, 3 figs. Canadian Tube and Steel Products, Ltd., Montreal, has become independent for their steel ingot and rod requirements through installation of electric steel-melting furnaces; installation consists of two Volta furnaces of Heroult type; electrode arrangements; furnace tilting; oxidation and reduction; low voltage use; ingot stripping.

Generators

HIGH-VOLTAGE. New Surge Generator. *Elec. Jl.*, vol. 28, no. 4, Apr. 1931, p. 245, 2 figs. Trend toward increased insulation for given operating voltage has necessitated higher and higher testing voltages in recent years; improved equipment to provide 1,000-kv. 60-cycle, and 3,000-kv. surge voltages has therefore been installed at Trafford High Voltage Laboratory; new equipment will greatly facilitate development work on insulation, as it is now necessary to determine performance on lightning voltages of all high-voltage apparatus.

High-Voltage Surge Testing, F. R. Benedict. *Elec. Jl.*, vol. 28, no. 4, Apr. 1931, pp. 216-218, 10 figs. In performing high-voltage surge tests on apparatus it is essential that shape of surge generator wave be under accurate control; steepness of wave front, magnitude of crest, and duration of tail can all be varied by use of proper circuit constants; elimination of oscillations at crest of wave is of considerable importance from standpoint of voltage measurement.

Grounding

CABLES. Der Doppelerdschlusstrom in Drehstromkabeln und seine Einwirkung auf benachbarte Fernmeldekabel (Double Ground Current in Three-Phase Cables and Its Effect on Nearby Telephone Cables), W. Wild. *Wissenschaftliche Veroeffentlichungen aus dem Siemens-Konzern*, vol. 10, 1931, pp. 51-77, 28 figs. Origin is studied on basis of equivalent circuit diagrams; it is concluded that, with considerations of loads already present before occurrence of double ground, net-works fed from one end are to be considered as networks fed from either end; protection is deduced from impedance diagrams; study of harmonics. Bibliography.

Heating

BUILDINGS. Building Heating. *Elec. Rev.*, vol. 108, no. 2786, Apr. 17, 1931, pp. 689-690, 3 figs. Advantages of load are such as to justify low rates; notes on electrode boiler and thermal storage; tabular and panel heating; electricity and heating load.

Hydroelectric

PIPE LINES. Design of Pipe lines for Hydroelectric Plants, J. S. Carpenter. *Power Plant Eng.*, vol. 35, no. 7, Apr. 1, 1931, pp. 418-419. To secure most economical design of pipe line for given condition, diameter and thickness are figured by modification of Enger's formula.

POWER PLANTS. The Economics of Power Plant Design, H. G. Acres. *Elec. News*, vol. 40, no. 7, Apr. 1, 1931, pp. 36-38 and 47, 8 figs. Fixed charges and operating expenses should be considered as definite factors in design of all plants; this is well illustrated in design and construction of recently completed development for municipality of Edmundston, New Brunswick.

Hydroelectric Units Operated as Condensers, H. A. Von Eiff. *Power*, vol. 73, no. 17, Apr. 28, 1931, pp. 666-669, 5 figs. Operating hydroelectric units as synchronous condensers under certain load conditions offers possibilities of large economies in plant operation; units in Holtwood plant of Pennsylvania Water and Power Company operated as condensers; method of solving problems encountered in operation and saving attained from condenser operation; curves of water saving by condenser operation on 25-60 cycle system; power for condenser operation.

Automatic Operator for 60,000-Hp. Station, A. C. Clogher and E. N. Peterson. *Elec. World*, vol. 97, no. 16, Apr. 18, 1931, pp. 716-722, 7 figs. Control of system frequency, division of load between units and change of one unit from generator to condenser operation are automatically and successfully performed at Morony hydroelectric development of Montana Power Co.; station is located on Missouri River about 18 mi. below Great Falls, Mont.; two 22,500-kw. units are installed.

Rock Island—A Power Development on the Columbia River, T. B. Parker. *Elec. Light and Power*, vol. 9, no. 5, May 1931, pp. 22-27, 7 figs. Hydroelectric development is being built for Washington Electric Co., subsidiary of Puget Sound Power & Light Co., principal distributor of power in western Washington; it will be first large low-head development in Northwest; designed for ultimate capacity of 150,000 kw. under normal head of 48 ft.; initial installation will be 60,000 kw.

Industrial Progress

RUSSIA. Russia. H. L. Cooper. *Engrs. and Eng.*, vol. 48, no. 4, Apr. 1931, pp. 76-86. How communism has come about, as told by consulting engineer for 800,000-hp. hydroelectric and navigation project under construction on Dnieper River in Russia; statistics of Dniebrostrol hydroelectric projects; organization and how work is being done; statistics about Dnieprostrol hydroelectric development; notes on Five-Year Program.

Insulation

The Physics of Insulating Materials—V, A. M. Thomas. *World Power*, vol. 15, no. 88, Apr. 1931, pp. 307-310. Failure of dielectrics under stress; discharge in solids; mechanical deformation of dielectric due to electric force. Bibliography.

LINES, HIGH TENSION. Performance of Wood Insulation in Transmission Lines, F. E. Andrews. *Elec. World*, vol. 97, no. 17, Apr. 25, 1931, pp. 780-782, 5 figs. No interruptions due to lightning flashover on modern lines by line trip-outs and no cases of 60 cycle power arcs following lightning flashover are recorded for 1930 on 90 mi. of all-wood constructed 33-kv. lines on Public Service Co. of Northern Illinois' system; this performance compares with respective figures of 42 and 30 for same items per 100 miles of line on 1025 mi. of previous construction.

MACHINERY. What is Good Insulation on Electrical Machines, J. L. Rylander. *Power*, vol. 73, no. 11, Mar. 17, 1931, pp. 438-441, 5 figs. Insulation failure is common evil of all electrical equipment; outline of methods for determining failure when cleaning and drying of electrical machine; effect of moisture and temperature; insulation values of different types of electrical machines as determined by tests.

MICA. The Permittivity and Power Factor of Micas, C. C. Hannah and E. Goodall. *Instn. Elec. Engrs.—Jl.*, vol. 69, no. 412, Apr. 1931, pp. 490-496, 5 figs. Attention is drawn to electrode difficulty in testing mica, and tests are described which show order of contact effect which may be obtained with ordinary mercury electrodes; means are described by which electrode contact effect with mica may be entirely eliminated, and test results are given proving this point; test results on power factor and permittivity of ruby, green, and amber micas are given.

Light and Lighting

HIGHWAY. Illuminated Highways are Safer, D. M. Diggs. *Nat. Safety News*, vol. 23, no. 5, May 1931, pp. 19-20, 58 and 60, 5 figs. Examples showing that modern highway lighting lessens dangers that lurk in darkness and aids night travel.

INDUSTRIAL. Maintenance of the Illumination System of an Industrial Plant, R. C. Smith. *Mech. Eng.*, vol. 53, no. 5, May 1931, pp. 371-375, 6 figs. Details and results of efficiency and depreciation study of shop-lighting fixtures undertaken to obtain definite data upon which to base recommendations regarding lamp renewals and cleaning schedules. Before "Three-M" Management, Materials, Maintenance) Congress, Cleveland, Ohio, previously indexed from advance paper.

MEASUREMENT. The Photoelectric Cell and Electric Clock as a Means of Recording the Daily Hours of Bright Sunshine, W. A. Thomson. *Can. Jl. Research*, vol. 4, no. 3, Mar. 1931, pp. 299-303, 2 figs. Method is presented whereby accurate record of daily hours of bright sunshine is made by electric clock, controlled, through relay, by intensity of light incident upon cathodes of suitably exposed photoelectric cell.

Lightning

MEASUREMENTS. Instruments for Lightning Measurements, C. M. Foust. *Gen. Elec. Rev.*, vol. 34, no. 4, Apr. 1931, pp. 235-246, 35 figs. Latest developments and applications of surge-voltage recorders; cathode-ray oscillographs; lightning-stroke recorders; surge indicators; lightning-severity meter.

Lightning Arrester

The Theory of Surge Absorbers, J. M. Thomson. *Elec. News* vol. 40, no. 9, May 1, 1931, pp. 41-42, 2 figs. Device that is essentially air core inductance connected in series with line, close to apparatus to be protected, and is operated by wave-front steepness of surge.

Magnetic Testing

IRON AND STEEL. Non-Destructive Tests by the Magnetic Dust Method. A. V. deForest. *Iron Age*, vol. 127, no. 20, May 14, 1931, pp. 1594-1595, 2 figs. Methods using magnetized iron filings for detecting cracks in ground surfaces, fatigue cracks in forgings and defects in seamless tubing; reference to work by W. E. Hoke and T. R. Watts. Before Am. Soc. Steel Treating and Am. Welding Soc.

Motor-Generators

Automatic Emergency Generating Sets. D. A. Bower. *Power Engr.*, vol. 26, no. 300, Mar. 1931, pp. 86-89 and 109, 5 figs. Sources of emergency supplies; development of emergency generating sets; principle of operation; general arrangement of emergency flywheel generating set; emergency set performing mechanical work; general layout of flywheel generating set arranged normally to perform mechanical work.

Motors

FRACTIONAL HORSEPOWER. The Woods High-Torque Fractional Horse-Power Motor, *Engineering*, vol. 131, no. 3408, May 8, 1931, p. 604, 3 figs. This type of motor has disadvantage of requiring commutator, which introduces complication that may easily lead to breakdown; moreover, to short-circuit rotor windings when motor has run up to speed, it is necessary to employ either brush-lifting device or segmental brush; to overcome disadvantages M. W. Woods, London, have designed line of machines in outputs ranging from 1/8 to 1/4 hp. at speeds of from 2800 to 700 r. p. m.

STANDARDIZATION. Adaptable Electric Motors. E. G. Ross, *Elec. Rev.*, vol. 108, no. 2786, Apr. 17, 1931, pp. 664-665, 1 fig. Analysis of "special" requirements of mechanical firms shows that they can be so classified as to render perfectly feasible issuance of British Standard Specification covering exterior shapes of motors of from 1-hp. to 250-hp. rating, while simultaneously making clear that any radical production alterations are not involved.

Networks

DESIGN. Network Promises Marked Economies. D. K. Blake. *Elec. World*, vol. 97, no. 11, Mar. 14, 1931, pp. 492-495, 10 figs. Network principle promises to reduce light and power system cost and to improve service standards if it is applied to several voltage levels used in industry, simplifies system layout and engineering, makes possible manufacture of standard apparatus of single rating on production scale and reduces system investment per unit of capacity and improves service standards at minimum cost.

An A-C. System of Distribution. J. P. Heslop. *Elec. Rev.*, vol. 108, no. 2783, Mar. 27, 1931, p. 544, 2 figs. System described is claimed to possess flexibility and economy of a-c. with reliability of d-c. operation; oil circuit breakers are installed in power station only, adjacent substations being supplied from different feeders.

Designing 115-230 Volt Distribution for Modern Residential Districts. G. L. Lillie. *Elec. News*, vol. 40, no. 9, May 1, 1931, pp. 37-40 and 50, 10 figs. Fundamentals of economical service outlined; transformer should be spaced 400-600 ft. apart; secondary conductors vary from no. 0 to no. 0000.

INTERCONNECTED. Transmission and Interconnection. P. M. Downing. *Elec. Light and Power*, vol. 9, no. 5, May 1931, pp. 20-21. California's experience in diversity, load factor, rural electrification. That percentage of homes wired is direct criterion of country-wide results to be expected from extension of transmission lines and their interconnection.

Phase Advancers

The Theory and Performance of Phase Advancers. J. J. Rudra and M. Walker. *Instn. Elec. Engrs.—Jl.*, vol. 69, no. 412, Apr. 1931, pp. 445-469 and (discussion) 469-486, also author's closure 486-489, 52 figs. Advancers are divided into "expedor" advancers in which voltage is proportional to secondary current, and "susceptor" advancers in which it is proportional to secondary voltage; effect of these are considered when connected to ideal motor having circle diagram of infinite radius and sets out simple relations between angle of advancer and kva. required to do what is desired.

Photoelectric Cells

Progress in Photoelectric Cells. A. J. McMaster. *Radio Industries*, vol. 5, no. 12, Apr. 1931, pp. 597-598 and 612-613, 3 figs. Types of light sensitive cells; theory of photoelectric action; cell manufacture; application; operating requirements.

Potentiometers

An Improved Feussner Type Potentiometer. M. Eppley and W. R. Gray. *Rev. Sci. Instruments*, vol. 2, no. 4, Apr. 1931, pp. 242-249, 7 figs. There are two improvements in design that can be made, one to both earlier and later forms as currently imported into United States, other to later self-checking type only; they are elimination of six contact resistances affecting measuring circuit, and addition of another standard cell dial, making it possible to adjust standard cell circuit to five places instead of to only four.

Power Factor

Checking Reverse Relay Connections. C. F. Dalziel. *Elec. West*, vol. 66, no. 4, Apr. 1, 1931, pp. 180-181, 2 figs. Most expedient method of over-all check is to connect voltmeter and ammeter in circuit with wattmeter, and from readings taken as outlined, sufficient data are obtained in order to permit power factor and "system" present to be computed; wattmeter readings obtained using voltage from potential terminals of relay. (Concluded.)

Controlling Power Factor Automatically. A. Smith. *Power*, vol. 73, no. 16, Apr. 21, 1931, pp. 632-634, 3 figs. By proper selection of motors in large industrial plant it is possible, by automatically controlling field current of large synchronous motor, to maintain plant power factor at unity; favorable power rate is obtained because of high power factor and other operating conditions; charts of power factor, incoming plant kilowatts and voltage recorded by graphic instruments; operating results.

IMPROVEMENT. Synchronous Motors Will Solve the Power Factor Problem. *Ry. Elec. Engr.*, vol. 22, no. 4, Apr. 1931, pp. 100-101 and 114, 1 fig. Modern machines combined with simplified control equipment have resulted in many successful applications that were once considered impracticable.

MEASUREMENT. Simple Power-Factor Measurement. O. Wiemer. *Elec. West*, vol. 66, no. 4, Apr. 1, 1931, pp. 186-187, 2 figs. The only instrument available is a-c. ammeter of suitable range, it is still possible and often very convenient to make power factor test; this can be done by three-ammeter method; method does not necessarily require use of three separate ammeters as name would seem to imply; equally satisfactory results can usually be obtained with only one ammeter if few simple precautions are taken.

Power Supply

RURAL. Rural Electrification Progresses in Illinois. R. Boonstra. *Elec. World*, vol. 97, no. 15, Apr. 11, 1931, pp. 693-694. Progress in rural electrification made by Public Service Co. of Northern Ill. during 1930 indicates that much can be done even by business year in extending lines to farm customers and in promoting use of energy by those customers.

Radio

AMPLIFIERS. A New Method of Testing for Distortion in Audio-Frequency Amplifiers. H. J. Reich. *Instn. Radio Engrs.—Proc.*, vol. 19, no. 3, Mar. 1931, pp. 415-435, 15 figs. Periodic voltage wave consisting of series of straight lines is distorted into series of curves when it passes through amplifier which gives nonuniform amplification; as such distortion can very readily be detected visually with oscillograph, it affords means of testing for uniformity of amplification; mathematical analysis shows that "saw-tooth" voltage wave is distorted into series of exponential curves in passing through resistance-capacity-coupled amplifier.

ANTENNAS. Radio Antennas. E. F. Martin. *Radio Eng.*, vol. 11, no. 4, Apr. 1931, pp. 39-41, 7 figs. Theory of antenna arrangements; their properties of transmission and reception.

BEACONS. A Radio Beacon and Receiving System for Blind Landing of Aircraft. D. Diamond and F. W. Dunmore. *Inst. Radio Engrs. Proc.*, vol. 19, no. 4, Apr., 1931, pp. 585-626, 29 figs., partly on supp. plate. Receiving system for use at airports to permit blind landing of aircraft under conditions of no visibility; system comprises three elements to indicate to pilot position of aircraft as it approaches and reaches instant of landing; same medium-frequency receiving set required for obtaining radiotelephone and radio range beacon service on airways is utilized for receiving runway localizing and marker beacon signals.

COILS—RESISTANCE. The High-Frequency Resistance of Coils. A. L. Green. *Experimental Wireless*, vol. 8, no. 91, Apr. 1931, pp. 183-191, 6 figs. It is shown that there are methods of measuring high-frequency resistance of coils which do not require use of thermo-junction and calibrated resistances; these methods depend on condition for oscillation in triode assembly, and simplest of them uses dynatron oscillator.

OSCILLATORS. Calculation of Electric and Magnetic Field Strength of any Oscillating Straight Conductors. R. Bechmann. *Inst. Radio Engrs.—Proc.*, vol. 19, no. 3, Mar. 1931, pp. 461-466, 1 fig. Theoretical mathematical analysis from results obtained by use of method which depends on formation of Hertzian vectors.

RECORDERS. An Automatic Recorder of Signals from A Rotating Beacon Transmitter. R. L. Smith-Rose and H. A. Thomas. *Sci. Instruments—Jl.*, vol. 8, no. 3, Mar. 1931, pp. 81-88, 5 figs. Automatic apparatus which has been developed for recording of wireless bearings from rotating beacon transmitter of type now in operation at Orfordness, Suffolk; output telephone signal current from standard type of valve receiver is supplied to tuned audio-frequency amplifier followed by rectifier; output current from this rectifier operates relay and pen which traces line record upon sheet of paper placed on rotating drum.

TRANSFORMERS. The Resistance Capacity Coupled Transformer. F. Aughtie. *Experimental Wireless*, vol. 8, no. 91, Apr. 1931, pp. 177-182, 7 figs. Use of choke in anode circuit and transformer primary being fed through suitable coupling condenser has long been known and used; authors favor circuit of where choke is replaced by resistance, by this substitution, besides removal of potential source of distortion, in shape of additional iron core, smaller self capacity of resistance as compared with choke, renders possible improvement in performance of stage at high frequencies.

ULTRA-SHORT WAVE. Ultra Short-Wave Radio-Telephony. *Elec. Rev.*, vol. 108, no. 2785, Apr. 10, 1931, pp. 622-623, 4 figs. Dover-Calais demonstration of radio-telephony on 18-cm. wave-length which marks striking advance in technique of electro-optical directive operation.

A New Wireless System. *Engineer*, vol. 151, no. 3926, Apr. 10, 1931, p. 413, 5 figs. Demonstration was given on Mar. 31 by International Telephone and Telegraph laboratories of "Le Matériel Téléphonique," of Paris; by means of new wireless telephone and telegraph equipment, largely developed by French engineers, in Paris laboratories, two-way telephone communication was established between Dover and Calais, on wavelength as low as 18 cm.

Railroad

ELECTRIFICATION. Suggestions as to the Future of Railroad Electrification. F. H. Shepard. *New York Railroad Club—Off. Proc.*, vol. 41, no. 5, Mar. 1931, pp. 9561-9653. Future outlook of electrification in America; reasons for extension.

Heavy Electric Traction Progress in America. C. Kerr, Jr. *Tramway and Ry. World*, vol. 69, no. 19, Apr. 16, 1931, pp. 187-190, 8 figs. Brief review of two outstanding installations; design, construction and operation and developments in locomotives motor development; control improvements; Delon trolley breakers, frequency changer sets.

POWER FACTOR IMPROVEMENT. Importance of Power Factor Improvement. W. K. Fuzzelle. *Ry. Elec. Engr.*, vol. 22, no. 3, Mar. 1931, pp. 76-78 and 85. Transmission and distribution systems loaded with wattless current cannot function economically; remedy lies in wider application of synchronous motor.

Rating

ELECTRIC MACHINERY. New Ratings for Electrical Machinery. *Elec. World*, vol. 97, no. 15, Apr. 11, 1931, p. 679. Recommendations of International Electrotechnical Commission proposed for international use at recent seventh plenary meeting, held in Stockholm *i. e.*, internationally specified limits of temperature rise for rotating machines and transformers; temperature rises reduced for use in tropical climates; tolerances allowable in electrical machine ratings.

Reactive Power

ELECTRIC METERING. Reactive Kva. Metering—VII. E. C. Goodale. *Elec. West*, vol. 66, no. 4, Apr. 1, 1931, pp. 181-183, 3 figs. Effect of unbalanced load upon accuracy of registration of three-phase three-wire reactive meters.

Rectifiers

CONTROL. On the Contact Conduction and Rectification. G. Hara. *Ryojun College of Eng.—Memoirs*, vol. 3, no. 4-A, 1931, pp. 223-224, 19 figs. Author intends to deduce approximate formula for contact conduction

applying cold emission theory to contact, and also to make clear mechanism of contact and rectification. Bibliography. (In English.)

Resistance

GROUND. The Measurement of Earth Resistances, G. F. Tagg. *Elec. Times*, vol. 79, no. 2061, Apr. 23, 1931, pp. 741-743, 6 figs. Regulations as to earthing; systematic tests; elementary methods of measurements; three point method; bridge methods; fall of potential method; Siemens-Halske earth tester; meggar earth tester; specific resistance of earth.

MOISTURE FILMS. Electrical Resistance of Moisture Films on Glazed Surfaces, G. G. Small, R. J. Brooksbank, and W. M. Thornton. *Instn. Elec. Engrs.—Jl.*, vol. 69, no. 411, Mar. 1931, pp. 427-436, 15 figs. Research is described in two parts, first dealing with relations between surface resistivity, humidity and temperature, and second with influence of gas pressure, both having for their object discovery of laws of film formation under controlled conditions.

Spark Gaps

ELECTRODES. The Development of an Electron Emitting Alloy, O. S. Duffendack, R. A. Wolfe and D. W. Randolph. *Electrochem. Soc.—Advance Paper*, no. 59-17, Apr. 27, 1931, pp. 157-173, 11 figs. After many experiments, nickel alloy containing barium has been developed which is homogeneous in composition and readily reproducible; spark gaps having electrodes made of this alloy have very constant sparking voltages; alloy has marked electron emitting properties that make it valuable for use in various electrical devices; its uses in several ways are being developed.

Stability

ALTERNATORS. Power System Stability, F. A. Hamilton, Jr. *Eng. Jl.*, vol. 14, no. 4, Apr. 1931, pp. 227-242, 31 figs. Methods of predicting power limits under steady or transient conditions have been outlined in various publications and are available to system designers; paper presents in more elementary fashion certain concepts upon which these methods are based; factors which affect power limits are discussed and their interrelation illustrated; methods of increasing power limits are discussed.

Starting

ELECTRIC MACHINERY. The Starting Motors, J. Sachs. *A EG Progress*, vol. 7, no. 4, Apr. 1931, pp. 85-89, 3 figs. Starting processes obtaining with asynchronous and synchronous machines when employing starting motors; it is indicated by few examples that with large machine units, but particularly phase advancers, employment of starting motors exercises very favorable effects upon starting conditions, such as smaller apparent power consumption, smaller initial current surges and higher power factor.

Substations

RECTIFIER. La sous-station automatique d'éclairage de Cannes (Automatic Substation). *Genie Civil*, vol. 98, no. 5, Jan. 31, 1931, pp. 117-118, 4 figs.; see also brief translated abstract in *Power Engr.*, vol. 26, no. 301, Apr. 1931, p. 156. Equipment of Bergerie, Cannes substation converts 10,000-volt three-phase, 25-cycle supply into continuous current at 250 volts for lighting and general service; in order to avoid noise or other nuisance, mercury-vapor rectifier was adopted as converting equipment.

Switchboards

SPECIFICATIONS. Nema Panelboard and Distribution Board Standards. *Nat. Elec. Mfrs. Assn.—Pub.*, no. 31-4, Jan. 1931, 31 pp., 11 figs. Standards on design and construction of panelboards; switchboards; cabinets and equipment boxes; commercial standard practise.

SUPERVISORY CONTROL. Supervisory Control Equipment. *Elec. Rev.*, vol. 108, no. 2784, Apr. 3, 1931, p. 611, 2 figs. Supervisory equipment for remote control of three substations, two of rotary type for traction purposes and one of transformer type, of Auckland Electric Power Board in New Zealand, has recently been completed by Automatic Telephone Manufacturing Co., Ltd., in collaboration with Metropolitan-Vickers Electrical Co., Ltd.; descriptive details of apparatus is given.

Switchgear

LOSSES. Eddy Current Losses in Heavy Current Switchgear—II, J. E. Shaw. *World Power*, vol. 15, no. 88, Apr. 1931, pp. 295-299, 8 figs. Iron loss in mold steel, switch tops; experimental results of measurements discussed in detail; experimental investigation of iron loss in plate, due to single conductor carrying current definite distance from it. (Concluded.)

Synchronizers

CLOCKS, ELECTRIC. Ein funkenfreier Synchronisier-Apparat fuer Nach- und Vorellen (Spark Free Synchronizer for Lagging and Advanced Currents), H. Bock. *Zeit. fuer Instrumentenkunde*, vol. 51, no. 4, Apr. 1931, pp. 197-204, 5 figs. Synchronizing equipment, for electric pendulum clocks, is detailed.

Television

QUALITY. Quality of Television Images, D. K. Gannett. *Bell Laboratories Rec.*, vol. 9, no. 8, Apr. 1931, pp. 358-362, 5 figs. Since each cycle represents two picture elements, number of picture elements which could be received is 10,000 in second, or 625 in 1/16 of second; no matter how good television apparatus, therefore, no better quality picture could be obtained than containing 625 elements, or about 22 by 28 elements.

Transformers

Recent Progress in Large Transformers, R. M. Charley. *Instn. Elec. Engrs.—Preprint*, for mtg., Apr. 16, 1931, 15 pp., 16 figs. General description of progress made in recent years and examples illustrating present stage of art.

Ultra Violet

WINDOW GLASS. Glasses for Use with Invisible (Ultra-Violet and Infra-Red) Rays, S. English. *Jl. of Good Lighting*, vol. 24, Feb. 1931, pp. 27-31 and (discussion) 32-35, 13 figs.; see also *Nature (Lond.)*, vol. 127, no. 3200, Feb. 28, 1931, pp. 310-312, 2 figs. Nature of invisible rays; spectrum; characteristics of certain radiations; ultra-violet transparencies of two glasses of similar composition; relative transparencies of various glasses; ultra-violet transmission of various window glasses; effect of artificial aging on two types of ultra-violet glass; spectra of various ultra violet light sources; Wood's glass and fluorescence; light transmission and heat absorption of various glasses.

Vacuum Tubes

GLOW. A New Television Lamp, G. Gruskin. *Radio Industries*, vol. 5, no. 12, Apr. 1931, pp. 593 and 611-612, 1 fig. Development of radically improved type of point-source light by W. C. Taylor of Taylor Vacuum Products Co., does away with many limitations formerly ascribed to mechanical scanning; author has not yet been granted authority to release details of tube's construction or operating principles.

INDUSTRIAL APPLICATIONS. Vacuum Tubes in Industry, P. G. Weiller. *Radio Eng.*, vol. 11, no. 4, Apr. 1931, pp. 31-34, 4 figs. Important progress is being made in design and manufacture of mercury vapor rectifier tubes and tubes useful for automatic control of operating electric circuits; many opportunities await cooperative studies between tube engineers and engineers engaged in mechanical industries.

Voltage Regulators

The Application of the Induction Voltage Regulator, W. E. M. Ayres. *Instn. Elec. Engrs.—Preprint*, for mtg., Apr. 16, 1931, 11 pp., 21 figs. General application of induction regulators to feeder systems and distribution networks; problem of fully automatic control is dealt with and various methods of parallel working are discussed; point of application of regulator in system is considered from its practical and economic aspects.

Voltmeters

HARMONICS. Ein Oberwellen-Voltmeter (Harmonic Wave Voltmeter), R. Oetker. *Zeit. fuer Technische Physik*, vol. 12, no. 4, 1931, pp. 205-210, 10 figs. Description of simple and exact indicating instrument for effective value of harmonics of distorted voltage curve.

IONIC. The Ionic Wind Voltmeter and Thermo-Electrostatic Relay, W. M. Thornton and W. G. Thompson. *Instn. Elec. Engrs.—Jl.*, vol. 69, no. 412, Apr. 1931, pp. 533-544, 18 figs. Electric wind observed in neighborhood of highly charged point in air is caused by repulsion of ions which collide with uncharged molecules of air, thus giving to them velocity and, in effect, causing wind from point; instrument based on this action, termed "ionic wind voltmeter," was designed to indicate voltage of any system above few thousand volts by making earthed electrode part of hot-wire bridge.

Wave Filters

Extensions to the Theory and Design of Electric Wave-Filters, O. J. Zobel. *Bell System Tech. Jl.*, vol. 10, no. 2, Apr. 1931, pp. 283-341, 18 figs. Derivation and composition of wave-filter structures; designs of networks which simulate impedances of wave-filters, and of loaded lines; four Appendices contain new reactance and wave-filter frequency theorems, particular fixed transducer designs and certain equivalents.

Welding

ARC. Arc Welding in 1931, J. F. Lincoln. *West. Machy. World*, vol. 22, no. 2, Feb. 1931, pp. 65-66, 3 figs. Every year since war use of arc welding has gained greater momentum in practically every industry; regardless of economic outlook for 1931, it is safe to say that this process will be applied more widely and more frequently than in any preceding year; development of electrodes during past year for welding of various steel alloys will bring about much wider application of arc welding and in turn permit wider use of these alloy metals, particularly that of stainless steel and other corrosion-resisting metals.

Arc Welding Everdue, T. E. Jerabek. *Boiler Maker*, vol. 31, no. 3, Mar. 1931, pp. 68-69, 5 figs. Property of copper-silicon-manganese alloy, known as everdur; advantageous welding characteristics; procedure of metallic arc-welding process.

ARC-TESTING. Inspection Safeguards Quality, R. Kraus. *Welding Engr.*, vol. 16, no. 4, Apr. 1931, pp. 27-31, 14 figs. Inspection and testing methods of Westinghouse Co., with incorrect and correct sketches of welding procedure and layout of weld; testing of welders and dimensions of test specimens. Before Am. Soc. Testing Matls.

BOILER MANUFACTURE. New Technique in Welding is Result of Years of Scientific Research, K. B. Lydiard. *Pit and Quarry*, vol. 22, no. 2, Apr. 22, 1931, pp. 62-64, 11 figs. Results of investigations and laboratory experiments by research engineers of Babcock and Wilson; based on which technique was evolved which produces welds equal to or better than welded plate itself in tensile strength, shock resistance, ductility, and in ability to withstand repeated stresses; results obtained when this technique is used to weld carbon steel of firebox quality.

GAS PIPE LINES. Development and Results of Arc Welding of Gas Pipe Lines, H. C. Price. *Oil and Gas Jl.*, vol. 29, no. 48, Apr. 16, 1931, pp. 148 and 150. Review of development of electric welding of pipe lines, since 1928, with particular reference to long distance natural gas lines; operating practise; results; tests; advantages. Before Am. Gas Assn.

MACHINERY MANUFACTURE. Welded Construction Applied to Special Machinery, D. V. Waters. *Product Eng.*, vol. 2, no. 4, Apr. 1931, pp. 167-170, 6 figs. As result of development of acetylene and arc welding technique in recent years, welded steel construction in places where such construction was formerly deemed impracticable, is now used to good advantage; savings of both money and time in construction have resulted from use of welded steel; adaption of welding to special machine construction.

SHIPBUILDING. Electric Welding in the Construction of Sea-going Vessels, G. Wahl. *Shipbldg. and Mar. Engine Bldr.*, vol. 38, no. 251, Apr. 1931, pp. 321-326, 16 figs. Experimental ship constructed by Deutsche Werke in order to find new methods of electric welding applicable to shipbuilding and for training of welders; results of tests and conclusion. Before Instn. Engrs. and Shipbldrs. in Scotland.

VENTILATION DUCTS. Welded Fabrication of Ductwork, W. Spraragen. *Heat. and Vent.*, vol. 28, no. 3, Mar. 1931, pp. 54-57, 9 figs. Preparation of material in repetitive production work; types of joints; expansion and contraction; stack welding.

Welding Machines

SPOT. The Dyer Bench Spot Welder. *Engineering*, vol. 131, no. 3401, Mar. 20, 1931, p. 408, 1 fig. Bench-type welder manufactured by Dyer Welding Machine Corp., Independence, Mo.; arrangement it is claimed, enables various parts to be joined together at place where they are assembled, thus saving time; welder is capable of making 1,000 welds per hr. on no. 16 gage sheet, variation in heat necessary for different metals being obtained through medium of three-position switch, which is fixed to housing containing transformer.

Industrial Notes

The Holophane Company, Inc., 342 Madison Avenue, New York, announces the appointment of A. D. Cameron as manager. Mr. Cameron was formerly active in the lighting field as manager of the lighting and supply division, central station department, General Electric Company, Schenectady, N. Y. Later he was vice-president of the Hall Electric Heating Company, of Philadelphia.

Ohio Brass Insulators Conform to New NEMA Standards.—To meet the new standards for switch and bus insulators decided upon at the May meeting of the National Electrical Manufacturers Association, the Ohio Brass Company, Mansfield, Ohio, announces a new line ranging in voltage ratings from 7.5 kv. to 69 kv. These new insulators, which simplify the construction, maintenance and repair problems of the user and make it much easier to coordinate line and station insulation, are now available for immediate shipment.

Miniature Relays.—A new line of miniature relays to be known as "Mid-Gett" is being made in eight contact arrangements by Struthers Dunn, Inc., 129 N. Juniper Street, Philadelphia. They are on standard bases and measure 1⅞ in. by 2¾ in., and follow in detail the design of regular type Dunco relays, having the three-legged stool principle of construction, form-wound, moisture-proof coils, renewable contacts, accessible terminals, with moulded bases. They operate on from 6 to 120 volts alternating current, or 24 volts direct current, depending upon the coil used.

New Vulcanized Fibre Insulation.—A new insulating material known as Dilecto K-4 is being produced by the Continental-Diamond Fibre Company, Newark, Del., manufacturers of Bakelite materials and vulcanized fibre. In addition to unusually high electrical insulating properties, Dilecto K-4 has high thermal insulating efficiency, is odorless and does not attract odors. It is finding a wide use as breaker strips on electric refrigerator cabinets. The material, which is highly resistant to alkali solutions and to water and moisture, will be made in sheets, rods and tubes, and can be machined readily.

Telegraph Code for the Electrical Industry.—A standard telegraph code for the electrical industry, sponsored by NEMA and other electrical associations, has been compiled under expert supervision for the use of the entire electrical field, not only for economy in communication, but to provide means for more frequent, accurate and comprehensive exchange of information of immediate necessity. According to the announcement it is the first instance of an entire industry uniting on a general code, and its cheap distribution is dependent upon the response to the pre-publication offer as detailed in the prospectus which is available upon application to the National Electrical Manufacturers Association, 420 Lexington Avenue, New York.

Trade Literature

Motors.—Bulletin 209, 32 pp. Describes type "D" heavy duty direct-current motors. Reliance Electric & Engineering Company, 1042 Ivanhoe Road, Cleveland.

Bridge-Stop Control.—Bulletin, 4 pp. Describes the new EC & M dynamic braking, bridge-stop control. This braking equipment is used on electrically operated overhead traveling cranes. The Electric Controller & Mfg. Company, 2700 East 79th Street, Cleveland.

Magnetic Clutches.—Bulletin, 24 pp., "Keeping Pace With Machine Design." Describes the construction, application and operation of C-H magnetic clutches, including a full description of the newly developed C-H duplex clutch. Cutler-Hammer, Inc., 12th & St. Paul Avenue, Milwaukee.

Circuit Breakers.—Bulletin 484, 4 pp. Describes type DR line oil circuit breakers, manual and electrical remote control, up to 2,000 amperes, 15,000 volts; 3,000 amperes, 7,500 volts; 60 cycle ratings, automatic or non-automatic. These breakers are designed for indoor service where space is an important factor. Condit Electrical Manufacturing Corporation, Boston.

Mercury Arc Rectifiers.—Bulletin 1907, 16 pp. Describes steel tank mercury arc rectifiers for converting alternating to direct current over wide ranges of both voltage and current. The most general use of this equipment is in supplying power for electric traction systems, although it has certain industrial applications. Westinghouse Electric & Mfg. Company, East Pittsburgh.

Switchboards.—Bulletin 293, 18 pp. Describes Bull Dog "SaftoSwitch-Boards" type DF-30. These are of standardized sectional construction, totally steel enclosed, consisting of one or as many panels as desired, allowing changes or extensions, as requirements may demand. The scheme of standardization not only includes switches, but has been developed to cover air and oil circuit breakers, meters, etc. Bull Dog Electric Products Company, 7610 Jos. Campau Avenue, Detroit.

Hardness Testing Machine.—Bulletin, 24 pp. Describes the Firth Hardometer. This device extends the reliable Brinell method of hardness testing for use with thin materials, case hardened or nitrided surfaces, small parts, or any condition where a small indentation is necessary or desirable. The Firth hardometer differs from other instruments intended for the same purpose in that the diameter or diagonal of the impression is measured instead of the depth. Tinius Olsen Testing Machine Company, 500 No. 12th Street, Philadelphia.

Power Filter Unit.—Bulletin, 4 pp. Describes a new power filter unit which converts alternating current into pure, non-pulsating, humless direct current for use on telephones, sound-on-film, public address systems, inter-communication systems, clock and signal systems, magnetic chuck operation, elevator control and many other applications. The use of batteries in connection with the power filter unit is unnecessary, except where a standby source of direct current is required. Square D Company, 6060 Rivard Street, Detroit.

Potentiometer Pyrometers.—Catalog 1101, 48 pp. Describes a new line of potentiometer pyrometers having a broad application to industrial needs involving the measurement and control of temperatures, especially in the higher ranges. The introduction outlines the nature and field of the potentiometer principle as applied to pyrometers. The various types of these instruments include indicating, recording, controlling, multiple recording and multiple controlling. The Brown Instrument Company, Windrim & Wayne Streets, Philadelphia.

Lightning Arresters.—Bulletin 20365-A, 4 pp. Describes autovalve lightning arresters for the protection of railroad signal apparatus. Bulletin 20149-G, 4 pp., describes type SV autovalve lightning arresters for station use either indoors or outdoors, 1,000 to 220,000 volts. Bulletin 20013-K, 8 pp., describes type LV autovalve lightning arresters for the protection of distribution transformers. Bulletin 1737-F, 24 pp., is a comprehensive, illustrated publication describing autovalve arresters in general and the correct method of installation. Detailed engineering discussions, supplemented by drawings and diagrams, clarify many arrester problems. Westinghouse Electric & Mfg. Company, East Pittsburgh.